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A NEW

# METHOD

Paul OF Parnell

# CHEMISTRY;

INCLUDING THE

THEORY and PRACTICE of that *Art*:

Laid down on MECHANICAL PRINCIPLES, and accommodated to the *USES* of *LIFE*.

The whole making

A CLEAR and RATIONAL SYSTEM of

CHEMICAL PHILOSOPHY.

To which is prefix'd

A CRITICAL HISTORY of *CHEMISTRY* and *CHEMISTS*, *From the Origin of the Art to the present Time.*

Written by the very Learned

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Translated from the Printed Edition, Collated with the best MANUSCRIPT COPIES.

By *P. SHAW*, M.D. and *E. CHAMBERS*, Gent.

With additional Notes and Sculptures.

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# Advertiſement.

S*Ome of the advantages of this work are briefly touch'd upon by the author, in his own preface; to which we ſhall forbear making any addition, how ſtrongly ſoever we may be tempted thereto. We apprehend it ſafer to be ſparing on that point, and rather leave the reader to diſcover them by their own light, than by an officious zeal foreſtall his curioſity, or prepoſſeſs him with beauties, which may be only ſuch to our ſelves.*

*We are, perhaps, too nearly concern'd in the cauſe, to be admitted to ſpeak of it without ſuſpicion: for tho' it be only a ſort of ſecondary credit we pretend to from it; yet there are ſome circumſtances, which, for ought we know, may entitle us to the whole. 'Tis no ſecret, that the learned author has abandon'd this his lateſt offſpring: tho' it was known he had gone with it many years; and great preparations were made for the delivery; yet it at laſt came forth before its time. The truth is, he could not prevail on himſelf to let it go: his exceſſive ſcrupulouſneſs was not contented with a* nonum prematur in annum *twice over; and he had in all probability with-held it half an age longer, had it not arrived at ſtrength and maturity enough to make its eſcape, it ſelf. It was no ſooner in the world, than, with all the diſadvantages ſo irregular a birth had occaſioned, it found its admirers: unlick'd, uncompos'd, unſwaddled as it was,* rudis indigeſtaque moles, *yet there every where appear'd the ſenſible traces of an exquiſite form, which nothing could overpower or efface.*

*This mov'd us to take the unhappy fugitive under our care; and ſupply, in ſome meaſure, the wanted office of the natural parent. What we have done for it, let others ſay; the moſt tranſient view of its former, compared with its preſent, ſtate,*

*will eaſily ſhew it. In ſhort, we adjuſted and compoſed its diſlocated parts; pared off the redundant ones; dreſs'd it a-new; nay, and adorn'd and enrich'd it; with a concern and affection rarely ſhewn to the productions of other people.*

*If any miſconſtrue our intentions herein; and charge us with a crime in attempting to reſcue a valuable work, juſt ready to be ſacrificed to the cruel delicacy of its author; and making an offering of it to the public, which was in danger of being defrauded of its due; we have nothing to reply, but that we* ——count their cenſure praiſe.

*This does but put us on a footing with ſome of the greateſt and moſt deſerving perſons of many ages, who are on record for the ſame crime: if their names were rehearſed,* Boerhaave * *himſelf would be found of the number.*

* —Intellexeram, virum celeberrimum haud ita facilem in emittenda ſua in publicum, ideoque, ſi rogaretur, forte interceſſurum. Ergo ne ſic quidem, ut apparent alienâ evulgatæ curâ, diſplicituras vobis crediderim! Satius quippe arbitror, opus utile juvare publica commoda, quam idem inter manus nimis atque anxiè elegantis auctoris in omne ævum premi. Immodica ſanè elaboratiſſimæ perfectionis ſtudia optima quæque eripuere publico. *Præfat. ad Sermon. Seb. Vaillant de Struct. Florum.*

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# The AUTHOR's PREFACE.

WHAT we are now entring upon, is a *Body of Chemistry*; deliver'd in clear terms; founded on sure Principles; and rais'd with undeniable experiments: In the course whereof, will abundantly appear the vast extent and importance of the art; and the great share it has, not only in medicine, but in all the parts of natural philosophy, and the mechanic arts. To accomplish this the more distinctly, and fully, we divide the whole into three parts, *Historical*, *Theoretical*, and *Practical*.

In the *first*, We shall shew, from the most antient, and authentic remains of *history*, what the art originally was; in what country, at what time, and by what persons invented, cultivated, and improved; how it degenerated, and was corrupted; how, and by what hands it was again purged, and restored; and how, thro' various ages, nations, and authors, it is at length transmitted to us. A history of this kind, tho' not absolutely necessary to the knowledge of chemistry, would, yet, be wanting to the curiosity of such as apply 'emselves thereto; as nothing uses to be more interesting to an artist, than to know the rise and fate of his art. This part we chuse to call by the name *Prolegomena*.

*Secondly*, We shall lay down the *axioms*, or assumptions of chemistry; *i. e.* all the general truths which the particular experiments of chemists have hitherto demonstrated. These are what we assume, or take for granted; and the whole body of such universal truths, collected from all the particular ones, makes what we call the *Theory of Chemistry*.

For chemiſtry is no ſcience form'd *à priori*; 'tis no production of the human mind, framed by reaſoning and deduction: It took its riſe from a number of experiments caſually made, without any expectation of what follow'd; and was only reduced into an art or ſyſtem, by collecting and comparing the effects of ſuch unpremeditated experiments, and obſerving the uniform tendency thereof. So far, then, as a number of experiments agree to eſtabliſh any undoubted truth; ſo far they may be conſider'd as conſtituting the theory of chemiſtry.

Now, ſuch doctrine or theory is neceſſary to be premiſed to every art; and ſomething equivalent hereto, is practiſed by every artizan: To inſtruct his diſciples how to proceed orderly to the exerciſe of their art, he muſt lay them down the general truths or rules thereof. This may bear a little further illuſtration: All the experiments ever yet made, agree in this, That no chemical operation is perform'd without fluids; or that all chemical alteration is effected by means of ſome fluid: This, therefore, may be laid down as an univerſal truth, or axiom of chemiſtry.

Again, from infinite obſervations and experiments, it is found, that there is no fluid without fire; or that all fluid bodies, as water, oil, ſpirits, *&c.* entirely devoid of fire, become ſolids: conſequently, if there were no fire, all the bodies in nature would fix into one rigid, conſiſtent maſs. Whence it eaſily follows, that all operations are perform'd by means of fire: which is another univerſal truth.

Again, from a thouſand experiments, made by as many perſons, in different places, it appears that there is not one grain of fix'd ſalt in any part of an animal body: So that this, too, may be aſſumed as an axiom.

From the inſtances here brought, it eaſily appears, that the truths of chemiſtry are none of 'em deduced *à priori*, from any abſtract contemplations of the mind; but collected *à poſteriori*, from innumerable experiments. And ſuch truths may be conſider'd, either as univerſal phænomena, or canons of chemiſtry, or as combinations or ſyſtems of the particular truths collected, and digeſted therein.

Now, it were impoſſible to teach the practice of chemiſtry, to the purpoſe, without ſome ſuch previous theory. To give a novice a parcel of wormwood, for inſtance, and bid him diſtil, and get the ſpirit from it, would be in vain, unleſs he knew before-hand, this general truth, or axiom, That all plants, expoſed to a gentle

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heat, evaporate their moſt ſubtile volatile part; and that this part, caught, and collected in a cloſe veſſel, is the ſpirit required. We eſteem it, therefore, incumbent on us, before we proceed to the practice, to give a candid and ample detail of theſe general axioms, or aſſumptions.

*Thirdly*, We ſhall exhibit a courſe of chemical *operations*, or the actual changes producible in bodies, by attending to the laws, or axioms of the art. This part we have been converſant in now upwards of twenty years; and from the firſt, have found it neceſſary to go in a *new method*, differing very widely from what has been obſerv'd by the moſt celebrated chemiſts of *Europe* in their courſes, and lectures. All theſe authors we have been at the pains of reading over; and have every where found 'em as abrupt, and diſorderly, as they are ſcanty and defective: a tumultuary maſs of pharmaceutical proceſſes, without any certain deſign or coherence, is all they afford. The beſt of 'em is Monſieur *Lemery*, whoſe performance has gone thro' I don't know how many editions, in various languages; and yet nothing could be worſe concerted for ſuch as ſtudy the art: He begins with the very hardeſt part, metals; a great number of his proceſſes are merely calculated for the preparing of remedies; and his view, throughout the whole, is rather to furniſh the ſhops with medicines, than to inſtruct his readers in the knowledge of chemiſtry. But how hard and unjuſt is this on poor chemiſtry! To make an art a drudge to phyſic, which, in reality, is the principal part of all philoſophy!

The proceſſes of chemiſtry, 'tis true, are almoſt infinite; and it were impoſſible to exhibit all that the chemiſts have hitherto invented, in the courſe of a man's life.

The method we purſue, then, is to reduce all the moſt uſeful, and inſtructive ones, to certain claſſes; to begin with the moſt ſimple, and eaſy of theſe; and lay them down in ſuch a manner, as to ſerve for a baſis to the next; and thoſe, in their turn, to others; till we arrive at the moſt difficult, and complicated proceſſes, by an eaſy, and gradual aſcent: the ſecond operation being never required to the underſtanding of the firſt; nor the third to the ſecond; but the firſt always neceſſary to the ſecond, and that again to the third: ſo that there will be no occaſion for ever repeating the ſame operation. Two hundred proceſſes, conducted after this manner, will ſet all the fundamentals of the art to view; and a few canons, or general rules, ſubjoin'd to each proceſs, will open the way for all

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the other numberlefs proceffes to be perform'd: So that at the fame time that our reader has only the marrow of the art prefented him, he is really put in poffeffion of the whole bulk thereof.

In each procefs our Method fhall be, 1°, To exhibit the object. 2°, To explain the operation. 3°, To fhew the effects of the change therein. The genuine virtues, and medicinal properties of each production fhall be added; fuch, as we have approv'd them by abundant experience: And thefe we promife to defcribe in the moft fevere, and fcrupulous manner; far from any taint of the wild flights, and extravagancies ufual among the chemifts.

'Tis certain, medicine has fuffer'd extremely from this quarter; every chemift affixing virtues to his preparations at random. Thus, falts drawn from the afhes of plants, having, on fome occafions, been found of fervice in tertians and quartans; immediately an anti-febrific virtue is affign'd thereto; and they muft be adminifter'd, in all fevers, indifferently: when, 'tis certain, that in inflammatory fevers they promote the difeafe, and haften death. Indeed, the chemifts fhould always be fufpected, when they boaft of general virtues in their preparations: There is nothing fo precarious, and ill-warranted as fuch pretences; nor can a man foberly fay there is any fuch thing as one preparation always effectual in any difeafe; no univerfal febrifuge, for inftance, againft all fevers; nor general lithontriptic, in all cafes of the ftone.

# *A* TABLE *of* CONTENTS, *drawn up Analytically.*

## *Of the Prolegomena, or Hiſtory of Chemiſtry.*



## *Of the Theory of Chemiſtry.*

Of

## *Of the Practice of Chemiſtry.*



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# PART I.

# PROLEGOMENA,

## OR THE

## Hiſtory of Chemiſtry.

THE firſt thing that occurs in our undertaking, is the word *chemiſtry*, which in *Greek* ſhould be wrote χημια, and in *Latin* and *Engliſh*, *chemia* and *chemiſtry*, not as uſual, *chymia* and *chymiſtry*. *Origin of the name chemiſtry.*

The firſt author in whom the word is found, is *Plutarch*, who lived under the emperors *Domitian*, *Nerva*, and *Trajan*. That philoſopher, in his treatiſe of *Iſis* and *Oſiris*, takes occaſion to obſerve, That *Egypt* *, *in the ſacred dialect of the Country, was call'd by the ſame name as the* black *of the eye*, viz. χημια, *chemia*: by which he ſeems to intimate, that the word *chemia*, in the *Egyptian* language, ſignified *black*; and that the country, *Egypt*, might take its denomination from the *blackneſs* of the ſoil.

But the etymology and grammatical ſignification of the name is not ſo eaſily diſpatched. The critics and antiquaries, among whom it has been a great ſubject of enquiry, will not let it paſs without ſome further diſquiſition: Inſtead of *black*, ſome will have it originally denote *ſecret*, or *occult*; and derive it from the *Hebrew Chaman*, or *Haman*, a *myſtery*, whoſe radix is *Cham*. And, accordingly, *Plutarch* obſerves, that *Egypt*, in the ſame ſacred dialect, is ſometimes wrote in *Greek*, χαμια *Chamia*: whence the word is eaſily deduced further from *Cham*, eldeſt Son of *Noah*, by

* Αιγυπτοι ωσπερ τȣ μελȣ οφθαλμȣ χημιαν καλȣσιν.

whom *Egypt* was first peopled after the deluge, and from whom, in the scripture-style, it is call'd the *land of* Cham, or *Chem.* Now, that *Chaman*, or *Haman*, properly signifies *secret*, appears from the same *Plutarch*, who, mentioning an antient author, named *Menethes Sibonita*, who had asserted, that *Ammon*, and *Hammon*, were used to denote the god of *Egypt*; *Plutarch* * takes this occasion to observe, that in the *Egyptian* language, any thing secret or occult, was call'd by the same name αμμον, *Hammon.* Add, that *Hecatæus Abderita* notes *Ammon* to have been a common term of invocation, whereby the *Egyptians* call'd one another when out of the way, or not to be found; and hints, that it had no peculiar relation to their great god, which was the universe, otherwise than as he was *secret*, and invisible, and was hereby call'd to manifest himself. Lastly, the learned *Bochart* keeping to the same sense of the word, chuses to derive it from the *Arabic*, *Chema*, or *Kema*, to *hide*; adding, that there is an *Arabic* book of secrets, call'd by the same name *Kemi.*

What we gather from the whole, is, that our art, chemistry, should appear to have been originally thus denominated, because not fit to be divulged to the populace, but treasured up as a religious *secret.*

*Origin of the art, chemistry.*

Thus much for the origin, and literal use of the name: As to its technical use, we have no testimonies of so much antiquity. The first time χημια occurs, as denoting the Art we are speaking of, is in a *Greek* Manuscript of *Zozimus* the *Panopolitan*, preserv'd in the king's library at *Paris.* This author, whom they stile *Panopolitanus*, to distinguish him from the historian of his name, seems to have lived under the younger *Theodosius*, about 400 years after *Christ*, or at least near the beginning of the fifth century. He wrote several treatises, still extant in manuscript in the *French* king's library; from one of which, *Scaliger* has transcribed the following passage, in his notes on *Eusebius de præparat. evangel. The sacred writings say, there are a kind of dæmons who abuse women.* Hermes *testifies as much: And all our learning, both open and occult, confirms the account. What the divine writings relate, is, that the angels, enflamed with the desire of women, instructed 'em in all the works and mysteries of nature: For which indiscretion they were excluded heaven, as having taught men things unfit for 'em to know. The same scriptures add, that from hence arose the giants. Now our first most antient tradition, call'd* χημα, *is on these very arts: The book they were contain'd in, was call'd by the same name; and hence the art itself was call'd* χημια, *Chemia.*

The passage here refer'd to in the sacred writings, seems to be that in *Genesis*, where *Moses* calls the descendants of *Cain*, *sons of men*; and those of *Seth*, *sons of god.* And the same prophet adds, that the sons of God saw the daughters of men, went in unto them, and that giants thence arose. Which chimes in to a tittle with what is quoted by *Zozimus.*

This passage deserves to be well noted; as we shall hereafter have occasion to shew, that the posterity of *Cain* were skilful in chemistry. But

* Αμμονα το κεκρυμμενον ειναι λεγουσιν. De Isid. & Osir.

who this *Hermes* was, the hiſtorian alludes to, is hard to ſay; for none of his writings have ſurvived to our age: that lately publiſhed in *Italy*, under the name of *Hermes Triſmegiſtus*, being a manifeſt forgery.

It may be obſerved by the way, that the doctrine of dæmons here mention'd by *Zozimus*, is expreſsly aſſerted by *Democritus*, *Plato*, *Philo Judæus*, and other philoſophers; who repreſent them as endow'd with a penetrating mind, and boundleſs knowledge; not confined to our ways of conceiving things relatively, but fitted to perceive them as they are in themſelves; not incumbred with a ſolid body, like us; but a penetrable one, like air. *Zozimus*, who adopts the doctrine with a peculiar fondneſs, obſerves further, that, beſide the intuitive knowledge of the dæmons, there was, even in the antediluvian world, a kind of human ſciences acquir'd only by reaſon and experiments; adding, that they in whom that latter knowledge was alone found, were denominated the *ſons of men*; and the former, the *ſons of God*. *Doctrine of dæmons.*

The ſame notion of dæmons prevails among many to this very day, under the name of ſpectres, or ſpirits, who roam about with their penetrable matter, capable of diſcovering themſelves to the human mind, and even of poſſeſſing the ſame, after the manner as the ſoul does the body. Divers inſtances of the ſame belief might be given from the antient Jews, and the earlieſt Chriſtians. Our Saviour himſelf was twice taken for a dæmon, or ſpirit, when he walk'd on the ſea, and after his reſurrection: to ſay nothing of the current opinion of the *Mahometans*, *Arabs*, and other *Aſiatics* and *Africans*.

Theſe dæmons too, of the antients, were ſuppoſed ſubject to human paſſions; they ſaw the daughters of men, and they loved them, and courted them in marriage; and, as an equivalent for their virginity, offer'd them a book, containing the whole body of their ſcience. The dowry was accepted, and call'd παράδοσιν θείαν, divine tradition; and this myſterious knowledge, χημα, *Chema*; ſometimes αποκαλυψις, revelation; and by *Zozimus*, την ἱεραν τεχνην, the ſacred art. *Philo Judæus* is full of theſe reveries; and from him *Zozimus*, in all likelihood, borrow'd half the incidents of the fable. *Chemiſtry reveal'd by 'em.*

This *Chema*, or *Chemia*, *Zozimus* will have the ſame with the antient *Cabbala* of the *Jews*; which periſh'd, with all their antiquities, in the deſtruction of *Jeruſalem*, excepting ſome fragments retrieved from the common ruin, and publiſhed in the *Thalmud*. Thoſe fragments are but few, and beſides, intermix'd with a world of trumpery. But *Zozimus* reſiding in the emperor's court, had an opportunity of peruſing many of the antient monuments then extant in thoſe libraries, which have ſince been plunder'd by the *Saracens*; ſo that his account carries with it the greater authority.

From the whole, it may be pretty ſafely argued, that whereas *Zozimus* deduces the name, and the art, χημια, from the angels, and ſuppoſes 'em communicated by them to their miſtreſſes; they muſt both be earlier than the flood: ſince the like intrigues related by *Moſes*, are expreſsly refer'd to the antediluvian ages.

*Origin of chemiſtry according to the mythologiſts.*

* The poets, and fabulous writers, give us a ſomewhat different origin of the antient *Chemia*: *Phœbus*, who is the *ſun* of the *Phenicians*, the *Ees*, or *Aaſch*, or *Mitra* of the *Perſians*, the ωρ or ορος of the *Greeks*, *Magi*, and *Jews*; the *Horus*, or *Deus gentium* of the *Latins*; and the God of light and phyſic among moſt of them; is ſaid to have fallen paſſionately in love with a beautiful nymph, named *Sibylla*. His divinity, we are told, at firſt met with ſome repulſe, till upon offering to comply with whatever terms ſhe could propoſe, ſhe conſented; and demanded, as the price of her favour, as many years as ſhe could hold grains of ſand in one hand, together with the Διος βουλη, the *heavenly wiſdom*, or divine *arcanum*; from whence the denomination *Sibylla* was derived. Which account, in the main, tallies well enough with that of *Zozimus*; for here, the ſon of a God, is in love with a maid, and reveals his father's ſecrets. And both relations may receive ſome light from the fable of *Prometheus*'s ſtealing the heavenly fire; which ſeems to refer to the ſame event.

After *Zozimus*, *Chemia* became a common term among the *Greek* writers, in the ſenſe 'tis now uſed. And if we hear nothing of it among the *Romans*, 'tis becauſe, after the tranſlation of the ſeat of empire to *Conſtantinople*, *Greek* becoming the court-language, ſcarce any thing was wrote

* The account given by *Zozimus*, is ſupported by the teſtimony of an author of more antiquity, *Clemens Alexandrinus*; who, in his *Stromata*, relates that the *angels, tho' choſe to inhabit heaven, devoting themſelves to the pleaſures of love, made a diſcovery to the women of ſuch things as they ſhould have kept ſecret; and hence*, ſays he, *all our knowledge of futurity, and of the ſublimeſt parts of ſcience.* This teſtimony, according to *Borrichius*, wants nothing but the *name* of chemiſtry; for as to the *thing*, it is plainly implied in the *ſublimeſt parts of ſcience.* But what gravels *Borrichius*, is the ſource from whence *Clemens* and *Zozimus* ſhould derive theſe facts; he concludes, however, that they had read them in the fragments of the writings of *Enoch*. *Sincellus* has preſerv'd us a paſſage in thoſe writings, which makes the matter clearly out: *The angels*, ſays *Enoch*, *taught women and men the uſe of charms, and remedies for diſeaſes. Exael, the tenth in order of the firſt angels, inſtructed them to make ſwords and bucklers, inſtruments of war, and works of gold and ſilver, paints, and precious ſtones for the women.* Now, *Sincellus*, according to *Borrichius*, is an author of credit; ſeveral hiſtorical facts were handed to him from *Manetho*, and *Julius Africanus*, which have ſince periſh'd; beſides that the paſſage now quoted, is confirm'd by a parallel one in *Tertullian*: *The fallen angels*, ſays that father, *firſt diſcovered to us the uſe of gold and ſilver, the art of dying, of painting the eye-brows*, &c. *And it was for this, that God firſt expell'd them heaven, as* Enoch *relates.*

*Borrichius* looks on theſe paſſages as ſo many authentic teſtimonies; but adds, That *Enoch* was miſtaken: The *angels* here ſpoke of, were not real angels; they were only the deſcendants of *Seth* and *Tubal-cain*, who degenerating from their anceſtors, gave themſelves up to unchaſte pleaſures with women deſcended from *Cain*; and among the tranſports thereof, divulged all the ſecrets God had truſted them withal.

Agreeably to this origin of chemiſtry, we find a view kept to love in the progreſs thereof. Hence, thoſe perpetual alluſions; the king's nuptial bed, *Vulcan's* net, the mixture of ſeeds, the flowing of the menſes; in a word, nothing in the affair of generation, but has its ſymbol in chemiſtry.

One would ſuſpect that the hiſtory of this art were partly borrow'd from the *Jewiſh* idolatry; their writings are full of the commerce between angels and women: but the effects thereof are repreſented as very fatal on both ſides. The unhappy paſſion occaſion'd angels to be expel'd from heaven; And the ſame, according to theſe writers, was the cauſe why Man was expel'd paradiſe.

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in *Latin*. They were most of them divines who treated of this art, which was conceiv'd to have a more immediate relation to religion. And hence it is scarce ever mentioned, but in terms that imply such relation: Of the *sacred* art: Of the *Egyptian* Art, της ἱερας τεχνης, *&c.*

But in the seventh century, when *Europe* was over-run with the *Barbarians* from the north, *Latin* and *Greek* shared the common fate of learning and arts; and not only the art, but the very name of *Chemia* was totally lost and forgotten. Thus they remain'd till the thirteenth century; when *Bacon* and *Ripley* retrieved, and brought them both on the stage again; not as old things, but taking them for a new doctrine and a new name.

## *Antiquity of Chemistry.*

E'ER we proceed to enquire into the antiquity and original of the practice of chemistry, it may be proper, by the way, to note, in what view we take the art; inasmuch as the different relations, or branches thereof, will furnish different æra's.

Chemistry, as now conceiv'd, is a system or assemblage of very different parts, which antiently subsisted separate, or at least had a subsistence prior to each other; as the preparing of metals for human uses; the transmutation of baser metals into gold; the procuring of medicines, *&c.* If, now, we go to trace the antiquity of chemistry, consider'd as it converts other metals into gold; or, as it prepares an universal remedy for all diseases; the research will not carry us far back: but as it relates to the discovery of metals in the mine, and the digging, separating, and purifying of the same, it challenges the highest antiquity. *Art of metals the most antient part of chemistry.*

In this last sense, therefore, it is that we purpose to search into the origin and antiquity of chemistry.

The art of metals is, no doubt, of a very early standing. To find, procure, fuse, refine, render malleable, and apply metals to use, is all of *Antediluvian* invention; and was attributed by the antients to their Gods. *Moses* the oldest author now extant, in his genealogy of the Patriarchs, *Gen.* 4. relates that *Tubal-cain* the eighth from *Adam*, was the *instructor of every artificer in brass and iron*, to prepare the instruments and utensils of life. Now 'tis apparent nothing of this could be effected without a thorough acquaintance with the metallurgic art. *Antiquity of the art of metals.* *First practised by* Tubal-cain.

For there is no metal requires greater art or industry, for instance, than *copper*, of which *brass* is made; its ore or glebe will sustain the utmost efforts of the fire, and the hammer, without yielding. According to the observations of *Laz. Ercherus*, *Agricola*, and *Helmont*, it must be put seven times successively in fusion, and each time well purged of its *scoria*, e'er it becomes ductile, and fit for use. All which requires no common stock of skill, as well as patience. *Tubal-cain*, therefore, being a master of the management of copper; there was nothing deep or difficult in all the *metallurgia*, but he must have understood.

Again, after copper, the most untractable of all metals, is *iron*. Its ore is a friable matter, pretty easily crumbled into powder; but 'tis with great

pains

pains, and the most vehement action of the fire and forge, that it is render'd malleable: yet this was practis'd long before the deluge.

This account of *Moses*, is surprizingly seconded, and confirm'd by prophane history and fables: *Diodorus Siculus*, who lived in the time of *Cæsar*, when *Egypt* was become a *Roman* province, had a fair opportunity of searching into the antiquities of the *Egyptians*: That author relates, as the result of his enquiry, a very antient tradition of one Ἥφαιστος, whom that people hold the first inventor of all the arts and operations about metals, and every thing else that undergoes the fire; together with their uses; which art he deliver'd down to posterity, so far as it might be of service to mankind. This Ἥφαιστος of the *Egyptians* and *Greeks* is the same with the *Mulciber* or *Vulcan* of the *Romans*, to whom the same art and invention is ascribed; and the *Vulcan* of the *Latins*, we shall make appear was the *Tubal-cain* of the *Hebrews*.

*Or by* Vulcan.

Several of the *Roman* antiquaries have labour'd to find the original of the very antient Name, *Vulcan*; but without Success; there being nothing in their Language that could lead to it. But *Vossius*, *Jo. Scaliger*, and *Bochart* have determined the point; and *Vulcan*, by the unanimous consent of the learned, is now acknowledged תּוּבַלְקַיִן *Tuvalcain* or *Tubalcain*. The relation between the words is pretty obvious at first sight; but a little grammatical inquiry makes it much more so: The learned in that language know very well that the first letter of the word, *viz.* *t* is servile, and does not belong to the root; this, therefore being set aside, the word stands *Vualcain*, out of which *Vulcan* is easily form'd: But this being a point of some consequence, as well as curiosity, it may deserve to be more particularly insisted on.

Tubalcain *and* Vulcan *one and the same person.*

The *Asiatic* nations then, we observe, divide their letters into *radical* and *servile*. The first are such as constitute a simple primitive word, or root, whereof others are form'd; as in the *Latin*, *Callus* is a root, whence, by addition of the servile Letters *o* and *s* is form'd *Callosus*; and in the *Greek* and *Latin* the Terminations ια ος and υς are frequently added as serviles. Now, among the *Asiaticks*, the letters ת, י, ו, are of the species of servile; which therefore being discarded, together with the points or vowels, which are merely arbitrary; we shall have בלקן which, by changing B into V, as is common, will be *Vulcan*, and adding the *Latin* termination *us*, *Vulcanus*.

Now it appears from *Homer*, *Hesiod*, *Orpheus*, and all the most antient Writers, that *Vulcan* had the art of working brass and iron; and that living under mount *Ætna*, he was employ'd in forging arms for the Gods and Heroes. As *Diodorus Siculus* relates the story, he was son of *Jupiter* and *Juno*, and the first king of *Egypt*; and that he was afterwards preferred to be a God; for having invented fire, and taught men the use of it. The discovery was occasion'd thus, * happening to see a tree on fire,

*Invention of fire.*

* The usual tradition is, that a philosopher meeting with some fire in a grove, preserved there by the Gods; and feeling it comfortable against the cold, sought how he might have the like, by throwing on Branches of Trees, &c. which gave him the first hint of a combustible matter.

kindled

kindled by lightening, he approached nearer thereto; and perceiving a ſenſe of heat, and withal, that the tree was ſenſibly conſumed, he caſt other wood on the blaze, and thus learnt that wood would maintain fire.

It muſt be added, that the *Egyptians*, as the ſame *Diodorus* obſerves, adored their God *Vulcan*, as the inventor of the whole art and application of metals; ſo that the accounts of *Moſes*, and *Diodorus* perfectly coincide, and plainly prove the Chemiſtry of metals almoſt coeval with mankind.

## *Where Chemiſtry was firſt invented.*

WE proceed in our enquiry to the place where chemiſtry had its birth; a ſubject famed for a mighty controverſy between the learned *Dane*, *Ol. Borrichius*, and that monſter of erudition *Her. Conringius*, which divided the chemiſts of *Europe* into two factions. *Borrichius* ſtrenuouſly attack'd the antiquity of the art, which *Conringius* as learnedly defended; between the two, however, abundance of points were admirably diſcuſs'd, which had otherwiſe never been regarded; ſo that the public was a gainer by the quarrel. Nor muſt *Voſſius* and *Bochart* be forgotten, from whom we have received divers curious things on the ſubject, which ſhew a wonderful harmony between the *Moſaic* and *Egyptian* Annals.

The *Babylonians* and *Egyptians* were in diſpute, for many ages, about the origin of the two nations; each advancing many weighty arguments, in proof of their own ſuperior antiquity. 'Tis hard to determine any thing upon the matter, eſpecially at this diſtance; but thus much muſt be allowed, that the God of the *Babylonians* was *Horus*, firſt king of *Aſſyria*,* and inventor of the art of medicine.

Now *Horus* ſignifies *fire*, and the *ſun*; under the firſt of which denominations the ſame deity was worſhip'd by the *Babylonians*, and under the ſecond by the *Perſians*. Whence we have a ſtrong preſumption, that this *Horus* was the ſame with *Vulcan*, or *Tubal-cain*; in regard each is held the inventor of fire: Beſide that *Tubal-cain* lived in *Meſopotamia*. But this we only advance by way of conjecture: indeed, ſince that noble treaſury of books, and manuſcripts, founded by *Calliſthenes* in *Babylonia*, in the time of *Alexander* the Great, were all miſerably deſtroy'd; we may deſpair of ever having any further light into the *Babyloniſh* affairs, from any authentic monuments of hiſtory.

By what can be gather'd from hiſtory, it appears pretty clearly that the art of chemiſtry was firſt found and cultivated in *Egypt*. In *Exodus* cap. XXXII. we read that *Moſes*, upon his coming down from mount *Sinai*, found a golden calf, which the *Hebrews* had been worſhipping; and that he reduced it into a powder, mix'd it with water, and gave it the people to drink. Chemiſtry then muſt have been underſtood by *Moſes*, and in perfection too; for 'tis certain, there are but very few among the chymiſts at this day, deep enough in the *Metallurgia* to do the like.

*Chemiſtry firſt practiſed in Egypt.*

Now *Moſes*, we are told, *Acts* 7. was educated in all the learning of the *Egyptians*.; which, if it be no direct and formal proof of chemiſtry's being

practiſed

practiſed at that time in *Egypt*; yet, is it of more weight, and concludes more than any other conſideration all hiſtory affords.

*Diodorus Siculus*, we have already obſerv'd, repreſents the *Egyptians* *Lib.* I. *c.* 2. as adoring *Vulcan* in quality of inventor of fire, and the art of metals. And the *Greeks*, who knew nothing of the name *Vulcan*, yet ſpeak of Ηφαιςιας in the ſame quality; and call *Egypt* itſelf γη ηφαιςια derived απο το Ηφαιςε *I burn*; which agrees with what has been afore ſaid. Again *Plutarch* de *Iſid.* & *Oſir. Edit. Par. Xylandri*, relates, that *Egypt* was call'd chemia, αιγυπτον χημιαν καλουν. But *Egypt* was alſo call'd the *black* country, the *hidden* country, *&c.* and the word chemiſtry itſelf has been ſhewn to have the ſame ſignification; ſo that every thing conſpires to one's wiſh.

Chemiſtry, therefore, is very properly denominated the *Egyptian Art*, as having been there firſt practiſed. Hence *Bochart* notes, that *Egypt* is to this day call'd by divers of the moſt antient *Aſiatic* Nations, *Chemi*, or *Chama*; as in the pſalms it is more than once call'd the land of *Ham*.

*Stephan. Byzantin.* relates that the *Greeks* call'd *Egypt* ἑρμηχημια, *Hermechemia*; but we have already hinted that they held *Hermes* the inventor of chemiſtry: which is a new confirmation.

And with ſo much zeal and religion did the *Egyptians* cultivate their *Chemia*; that *Herodotus* aſſures us, they had a temple in the city *Memphis* conſecrated to *Vulcan*, *the inventor of fire.*

Laſtly, *Diogen. Laert. de Vitis Philoſoph. Lib.* 7. informs us, that in *Zeno*'s explication of the word *Vulcan*, it ſignified *artificial fire.* Now ſumming up the whole, *Egypt*, land of *Cham* or *Chemi*, Ηερμηχημια, and γη ηφαιςια, and referring all to *Tubal-cain*, ſon of *Cham*; it will appear inconteſtable, that *Egypt* was the country where chemiſtry was firſt practiſed, and *Tubal-cain*, or *Vulcan* the inventor *.

* The country thus ſettled, the chemiſts go higher, to fix the preciſe place thereof where their art was firſt practiced. The generality put *Thebes*, call'd in the *Egyptian* ſtyle *No-Ammon*, where aſtronomy was firſt cultivated, in poſſeſſion of the firſt chemiſts: But *Borrichius* rather chuſes *Memphis* for the firſt theatre of the art; his chief reaſon is, that here was a temple erected to *Vulcan*, as the inventor of the art of working iron.

A reader that can take delight in antient, obſcure fables, and modern, learned gloſſes thereon, may here have his ſwing; the ſtories of *Hermes* and *Mercury* will ſet him up at once; the one king of *Egypt*, the other of *Italy*, but both the inventors of all arts, and chemiſtry in particular. For *Hermes*, as he was an *Egyptian*, and his ſtory ſo obſcure; there is no harm in admitting him: He might be *Vulcan*, for what we know, under another Denomination. But that ſame *Mercury*, who was alſo call'd *Faunus*, and is only ſaid to have carried his invention from *Italy* to *Egypt*, is in ſome meaſure excluded, by what has been ſhewn of the art's being of *Egyptian* original.

*Homer* indeed repreſents *Mercury* as the firſt, who found the art of managing fire; he alſo mentions *Apollo*'s opening *Hermes*'s cave, which was cover'd up with gold; *Venus*'s infidelity to her husband *Vulcan*, and her intrigue with *Mars*, in which the chemiſts plainly find the amalgama of iron and copper, or a perfect image of the grand operation. But inſtead of troubling the reader with any thing more in this kind, we refer him to *Borrichius de Ortu & Progreſſu Chemiæ. Conringius de Hermetica Medicina. Tollius de vitulo Aureo. Hornius*'s *Arca Noæ. Kircher's Oedipus Ægyptiacus. Voſſius de antiquis Medicis*: and *Bochart.*

E'er

*Several names and appellations of Chemistry.*

E'er we resume the thread of our history, it may be worth while to note the different names, which different nations and authors have given the art; and the rather, as they are all founded on some relation or circumstance thereof.

Its original or *Egyptian* name, then, we have observ'd was *Chemia*; the rise and signification whereof has been already adjusted.

Poesy, poietice.

Another very antient *Greek* denomination is *poietice*, ποιητικη, *i. e. poesy* or *poetry*; which we learn from *Zozimus*, who adds (without offence we hope to the poets) that the artists themselves were call'd ποιηται, poets, *q. d.* makers. It was also call'd *Chrysopoiesis*, χρυσοποιησις, and the artists χρυσοποιηται, *q. d.* gold-makers. See *Rainerius* on this head, *lib.* 2. *c.* 5.

Chrysopoiesis.

Alchemy.

The *Arabs* gave it the name *Alchemia* or *Alchemy*, by prefixing, after the manner of their language, the particle *al*, to the *Egyptian* name, to heighten the credit of the art. The æra of this term is fix'd at about four hundred years after Christ: The first author, who mentions it, is *Julius Firmicus Maternus*, who lived under *Constantine* the Great, and who in his *Mathesis*, c. 15. speaking of the influences of the heavenly bodies, affirms, that if the Moon be in the house of *Saturn*, when a child is born, he shall be skill'd in *Alchemy*.

Hyssopic Art.

*Paracelsus* oddly enough styles it the *hyssopic art*, from that passage in the psalms, *purge me with hyssop, and I shall be clean*, by reason chemistry purifies metals. It seems it was a *Jewish* custom to purify with hyssop; and according to *Paracelsus*, six of the metals are leprous, or impure, and to be purged of their leprosy by chemistry; therefore, like a strange coiner of words, as he was, he must call it the hyssopic art.

Hermetic and Trismegistic.

The *Hermetic* and *Trismegistic* art are appellations it derived from its supposed inventor *Hermes Trismegistus*, an antient king of *Egypt*, a thousand years prior to *Æsculapius*. *Trismegistus* is only a *Greek* title or quality added to *Hermes*, signifying as much as the *Latin ter maximus*, thrice-greatest. *Zozimus* mentions him as having wrote on natural things.

Pyrotechnia.

It is also call'd *Pyrotechnia*, or the *art of fire*; whence that mighty chemist, *Helmont*, denominates himself *philosopher by fire*.

Spagyric art.

Lastly, it is call'd the *Spagyric art*, some say, from παν and αγειρειν to separate and unite; inasmuch as it separates heterogeneous, and joins homogeneous things. But it will admit of some doubt, whether the antient *Adepti* were so well versed in the *Greek* Language.

## *Antiquity of Alchemy.*

HAVING shewn the antiquity of chemistry, consider'd with regard to the art of metals; it remains to consider the same with regard to the making of gold, and finding the philosopher's stone.

Now, chemistry taken in this light is usually call'd *Alchemy*, an *Arabic* word form'd by prefixing the augmentative particle *al*, to denote it the most eminent, and sublime part of the art: As, of *gebra* is form'd *algebra*, of *kermes alkermes*, &c. But it must here be remembred that the word

*Two different objects of Alchemy.* alchemy has a two-fold acceptation, reſpecting the two different things which it purſues: *viz.* 1. The ſecret of making gold from any other metal. 2. An univerſal medicine for the cure of all diſeaſes; which is a diſtinction of the utmoſt moment, in an inquiry into the origin of alchemy.

*Antiquity of the art of making gold.* Our firſt buſineſs then ſhall be to ſettle the æra of alchemy, as it propoſes the making of gold. This, we venture to ſay, is not near ſo antient as the art of metals; nor do we find any trace thereof before the third century. The chemiſts indeed go higher, and will abate nothing of the age of *Adam:* That patriarch, they ſay, was no ſtranger to the art of making gold; which he taught his deſcendants: tho' it had the fortune to be loſt at the flood; and was only reſtored by *Moſes*, and his ſiſter, by whom it has been handed down without interruption thro' the ſucceeding ages. But a matter of hiſtory is only to be demonſtrated from monuments of hiſtory; and the antient hiſtorians, poets, &c. are all perfectly ſilent, as to any ſuch thing. Neither *Orpheus*, *Homer*, nor *Heſiod*, nor any of the *Latin* ſcholiaſts *The antient Poets unacquainted therewith.* or antiquaries, or any of their commentators, mention any thing of the matter. And what would not the poets have given for ſuch a boundleſs *And philoſophers.* field of fiction and fancy? *Ariſtotle*, aſſiſted by *Alexander* the Great, maſter of all the antiquities of the *Perſians*, *Chaldeans*, *Babylonians*, *Egyptians*, *Hebrews*, and *Greeks*; this *Ariſtotle:* who deſcribed the properties of bodies, and all their phyſical mutations, has not one word of the philoſopher's-ſtone: And can it then be thought poſſible, the *Egyptians*, the people of *Aſia* and *India*, ſhou'd have had any ſuch ſecret? *Theophraſtus* was *Ariſtotle*'s diſciple; he writ of vegetables, ſtones, metals, and foſſils, of gold, ſilver, mercury, and all the minerals; and beſide his own ſtock of knowledge, was maſter of all the works of *Ariſtotle:* yet he takes no notice of the tranſmutation. *Pliny*, that indefatigable naturaliſt, who compiled his work from ſo many thouſand volumes; who ſearch'd with unwearied pains into every thing ſtrange, and out of the way; and who has comprehended almoſt all the monuments of art and nature within his pandects, never mentions any thing like a philoſopher's-ſtone, which ſhould tranſmute metals, in all their ſubſtance, into gold. In all the hiſtorians we find nothing to countenance this imaginary antiquity; nothing that ſhews it to have been talk'd of even in *Galen*'s time *. For we bar the conjectures which the chemiſts uſe to advance on this occaſion; as in truth they are no better than chimæras: What, for inſtance, can be more ſo than to find the

* *Suidas* endeavours to ward off this objection. *Diocletian*, he obſerves, procured all the books of the antient *Egyptians* to be burned; and it was in theſe books the great myſteries of chemiſtry were contain'd. *Conringius* calls this hiſtory in queſtion, and asks how *Suidas*, who lived but 500 years before us, ſhould know what happen'd 800 years before him? To which *Borrichius* anſwers, that he had learnt it of *Eudemus*, *Helladius*, *Zozimus*, *Pamphilus*, &c. as *Suidas* himſelf relates.

doctrine

doctrine of making gold couch'd in the story of the *Argonauts* *, the books of *Moses*, and the revelations? The same spirit might find the longitude, and the perpetual motion in the same.

The first author who has a tittle of the matter, is *Æneas Garæus*, a *Greek*, who lived towards the close of the fifth century, and wrote a comment on *Theophrastus*. In the latter part of the work, he has a passage to the following effect: *Such as are skill'd in the ways of nature, can take silver, and tin; and, changing their former nature, make them into gold.* This seems to imply as if some such art were then in being; but as he relates nothing expresly how long it had been known, his testimony will not carry us back beyond his own time: for we should assert no further than we find. The same author tells us he was wont to style himself χρυσοχόος, gold-finder, or χημευτής, chemist; and is the first who uses the word χρυσοποίησις, as applied to this art. *The first author who mentions it.*

The next is *Anastasius* the *Sinaite*, who is about fifty years posterior to *Garæus*. From a passage in this author we learn, that there were alchemists in his time. In a defence of himself against some Impeachments of his adversaries, he has these words; *You ought not to call us alchemists:* which is an argument there were people at that time who profess'd the art.

After these two authors, follow a croud of no less than fifty more, all on the subject of alchemy, all *Greeks*, and most, or all of them, monks; their names need not be rehears'd: the principal of 'em are *Syncellus*, *Rinesius*, *Stephanus*, *Olimpiodorus*, *Dioscurus*, *Ostanes*, &c.

The art seem'd now confined to the *Greeks*, and among them few wrote but the religious; who, from their great laziness, and solitary way of life, were led into vain enthusiastical speculations, to the great disservice, and adulteration of the art. The greater part of them are yet in manuscript, and like to continue so, till chemistry is more studied, or the chemists know more *Greek*. They are all wrote in the natural style of the school-men, full of jargon, grimace, and obscurity. *Among whom it was chiefly cultivated.*

Against what we have alledged concerning the novelty of alchemy, *Borrichius* quotes a passage from *Pliny*, *lib.* 33. *c.* 4. on which he lays a deal of stress and confidence. That naturalist observes, *There is one way of making gold, from orpiment*——Caius Caligula *was tempted by his avarice to make the experiment. Accordingly, he caus'd a considerable quantity of the mineral to be distill'd. The result was, that he did indeed obtain gold, and of the finest kind; but in so small quantity, and with so much labour and apparatus, that the profit not countervailing the expence, he desisted. His ill success has deter'd any body from ever making the like experiment* †. *Caligula's attempt.*

But

* *Suidas* will have the secret of the philosopher's-stone contained in the fable of the golden fleece; which, according to him, is a mere poetical fiction, describing the process of making gold. But unless he could bring better vouchers for his opinion, it will pass for no better than a fiction itself.

† *Borrichius* imagines, that what put *Caligula* upon the thought, was that oracle of

But this account makes very little for the pretenſions of *Borrichius*. Here was no tranſmutation of lead, or tin, into gold: no hint of any philoſopher's-ſtone; only, a ſmall quantity of gold was extracted. And no wonder; when we know that gold, more or leſs, is procurable, by ſeparation, from every metal: tho' it commonly proves *Caligula*'s caſe; the gold thus gain'd not being worth the fire.

Another paſſage which the chemiſts produce from the ſame author, makes ſtill leſs for their purpoſe. *In the reign of* Tiberius, *'tis reported, an artiſt had found the ſecret of tempering glaſs, ſo as to render it malleable; but the inventor was made away withal, and his work-houſe put down, for fear this new manufacture ſhould lower the value of gold, ſilver, and other metals. But this report was more current than certain.* Allowing the fact for true, we don't ſee what ſtead it will ſtand them in *.

*Antiquity of the universal medicine.*

Let us now ſee what pretenſions alchemy has to antiquity, conſider'd as it aims at an univerſal remedy, effectual in all diſeaſes; or even at any remedy at all. This appears, of all others, the lateſt branch of the art. Many are of opinion, that all preparation of metals, and other matters for medicinal uſes, was utterly unknown to the antients; and firſt introduced by *Paracelſus*.

*Borrichius*, however, pleads ſtrenuouſly for the antiquity of this branch; and employs a deal of learning and ſubtilty to prove it ante-diluvian, and *Hermes Triſmegiſtus* the author. Now, the fate of every art is only to be exhibited from the monuments of hiſtory: and ſome author ſhould here be produced to warrant this antiquity; by relating, that the art was invented, or cultivated in ſuch or ſuch an age.

But *Borrichius* will have it antient without any ſuch voucher: the chief ground he goes on, is a ſingle paſſage in St. *Jerom*, who ſpeaking of *Hermes*, ſays he was *a great phyſician*. But is this a proof of his having the art of making gold out of baſer metals, and of making a medicine by means thereof that ſhould cure all diſeaſes?

*No mention of it among the antient hiſtorians.*

Hiſtory, in effect, affords no ground for the opinion: *Moſes*, the oldeſt writer extant, and thoſe who came next after him, are ſilent on the point; and yet *Moſes* was an adept in all the diſcipline of the *Egyptians*, and relates the origin of all the Arts from *Adam* to *Noah*; and had a fair opportunity for this, in treating of the *Lepra* in *Leviticus*, had he known

of the *Sybils*, *Tetraſyllabus ſum, prima pars mei virum, ſecunda victoriam ſignificat*; which the chemiſts generally ſuppoſe to contain a myſtery, and to be ſpoke of arſenic, whereof orpiment is a ſpecies. Tho' *Kircher* will have the oracle applied to our Saviour.

* *Kircher*, indeed, aſſerts, that the theory of the philoſopher's-ſtone is contain'd in the table of *Hermes*; and that the antient *Egyptians* were not ignorant of the art, but declined to proſecute it. They did not need to tranſmute gold; they had ways of ſeparating it from all kind of bodies, from the very mud of the *Nile*, and ſtones of all kinds. But he adds, *theſe ſecrets were never wrote down, or made publick, but confined to the royal family, and handed down traditionally from father to ſon.* So that all ſtrict evidence is at once excluded.

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it. From *Moses* to the *Babylonish* captivity, we have no historian: the first that appears, is the *Phœnician, Sanchoniatho,* who was cotemporary with *Zerobabel:* to him we are indebted for what we know of the *Phœnician* and *Grecian* antiquities; but he has not one word of the philosopher's-stone, or the grand medicine. *Herodotus* and *Thucydides* don't afford us any more light; and yet the former is very particular in enumerating the arts of the *Egyptians.* He adds, somewhere, "that *Darius Hystaspes* having broke his leg, sent for physicians from *Egypt*; but that the "cure did not succeed to his expectation, till a physician of the family of "the *Asclepiades* was call'd in." But no mention here of any universal medicine. Consult *Dioscorides,* who travel'd thro' *Chaldea, Persia, Babylon, Egypt, Africa, Europe,* and other regions, and collected every thing relating to the art of physic: does he mention any thing of an universal medicine? Not a syllable. *Ætius* collected his *Tetrabiblos* from all the writers then known, and from a thousand now lost: he is very express in rehearsing all the *arcana* for the several diseases; and his work is a kind of index, or inventory of all antiquity. Yet no hint of any such medicine in him. Ask *Hippocrates,* who, according to *Zoranus*'s account, pass'd thro' all *Egypt, Africa,* and the coasts of the mediterranean sea, to make discoveries and improvements in his art; and ask *Galen,* too, who was no less laborious an enquirer, why they all took such pains, by slow, imperceptible means to improve their art, when they had it in their power to cure all the Infirmities of human nature, by a single preparation, known to so many persons? Is it possible that *Galen,* who published an account of all the sects and writers among the physicians, should be so inadvertent as to forget so singular a body of enthusiastical quacks; had they been then in being? A pretender to an universal remedy could never have escaped the gall of his pen.

*Or antient physicians.*

'Tis highly probable it was the *Arab, Geber,* that first occasion'd people to turn their thoughts this way; and set them a madding after such a medicine. His words are, *There is a medicine which cures all lepers, or leprous persons.* But by attending to the *Arabic* style, and diction of this author, which, according to the genius of that language abounds in allegory, it will appear, that by *man,* he means gold; and by diseases, or *lepers,* the other metals, which all recede, more or less, from the purity and perfection of gold.

*Whence the thought first arose.*

## *Authors and Improvers of Chemistry.*

THE *Origines* of chemistry, or the first rudiments of the art, thus laid, we proceed to relate the progress thereof; and who the principal authors were that contributed to its advancement, as well as those who corrupted it; at the same time noting their several writings, the best editions thereof, and the order wherein they are to be read.

And here we judge it proper to distinguish the chemists into three classes; either as they treat of metals, of alchemy, or medicine.

*Different kinds of chemists.*

ZOZIMUS

400. Zozimus. **Zozimus** the *Panopolitan* leads the band of chemical authors *. The circumstances of principal note in his history we have already related. His writings are, 1°, περι της ιερας τεχνης τȣ χρυσȣ και τȣ αργυρȣ ποιησιος, Of the divine art of making gold and silver. 2°, περι της γης, Of the virtue and composition of earth. 3°, περι των οργανων και καμινων, Of chemical instruments and furnaces. 4°, περι της υλης ακαυστȣς, Of the incumbustible matter. As also, 5°, Of *waters*. 6°, Of *divine arts*. And, lastly, of *mysteries*. They had lain a long time conceal'd in the *French* king's library; and had the fortune to be first ddiscovered by *Jos. Scaliger*; as he himself relates in his notes on *Eusebius*; since whom, they have also been perused by *Borrichius*, *Conringius*, and *Rheinesius*.

700. [illegible] other [illegible]eks. After *Zozimus* came a troop of *Greek* monks, *Garæus*, *Anastasius*, and fifty more, of whom we know little more than the names. There is nothing extant in print of any of them; but their writings are still found in manuscript in the great libraries of *Rome*, *Venice*, and *Paris*. 'Tis, perhaps, no great detriment to the art, in the main, that they are not more known, and read; there being a vein of rhodomontade and obscurity running thro' 'em, which might give ill impressions on the art. After these *Greeks*, came the *Arabs*.

800. Geber. **Geber**, surnamed the *Arab*, presents himself as the first great reformer and improver of chemistry. His history is very obscure: The name *Geber* in the *Arabic* language signifies a *great man*, and a *king*; whence he is commonly supposed to have been a prince; and, as he wrote in *Arabic*, a prince of *Arabia*. But *Leo Africanus*, a *Greek*, who wrote of the antiquity of the *Arabs*, gives another account. *Geber*, according to this writer, *lib.* 3. *c.* 106. was originally a *Greek*, and a christian; but afterwards embraced mahometanism; went over into *Asia*, and there learn'd the *Arabic* tongue. He adds, that his book was wrote in *Greek*, and translated thence into *Arabic*; and that he was not known by the name *Geber*, till after this version.

*Golius*, professor of the oriental languages in the university of *Leiden*, made the first present of *Geber's* piece, in manuscript, to the publick library; and translated it into *Latin*, and publish'd it in the same city, *in Folio*; and afterwards *in Quarto*, under the title of *Lapis Philosophorum*. It contains abundance of curious and useful things about the nature of metals, their purification, fusion, malleability, *&c.* with excellent accounts of salts, and *aquæ fortes*. Abundance of his experiments are verified by present practice; and several of them have pass'd for modern Discoveries. Except for what relates to the philosopher's-stone, the exactness of his operations is really surprizing. He seems to have liv'd in the 8th century.

* We have chemical writings, indeed, which pretend to much greater antiquity; but they are all apparently spurious and modern: such is the *table of emeralds* attributed to *Hermes*, notwithstanding all *Borrichius* can do to prove it antique: 'tis not once mention'd in any author of any standing. Such also are the books of *Solomon*, *Mary the prophetess*, *Ostan*, *Democritus*, &c.

He

He is ſuppoſed to have given the firſt handle to any enquiry after an univerſal medicine; there being ſome expreſſions in his book, which might eaſily enough lead an unwary reader to think he was acquainted therewith. As, *Gold thus prepared cures lepra's*, *cures all diſeaſes*, &c. But we are here to obſerve, that in his language, the coarſer metals are all leprous men; and gold a healthy one. When, therefore, he ſays, *I will cure ſix lepers*, he means no more than that he will turn them into gold, which ſhall bear the tryal of antimony. But as he was no phyſician, 'tis more than probable he never thought of any univerſal remedy himſelf. After this writer, we don't meet with any other of diſtinction, till the 12th century.

ALBERTUS MAGNUS began to flouriſh in this age, born in the year 1200; was firſt a monk, then biſhop of *Ratisbon*. He diſtinguiſh'd himſelf chiefly as a philoſopher: but this did not hinder his having a peculiar devotion to chemiſtry. By a general correſpondence with all the miners throughout *Germany*, he got a very uncommon inſight into the art of metals. 1200. Albertus Magnus.

He wrote a great number of books, on various ſubjects; as, *de ſecretis mulierum*, &c. But his chemical works are few, and thoſe very hard to be met withal *.

ROGER BACON, vulgarly call'd *Friar Bacon*, made his appearance about the ſame time; the glory, and at the ſame time the ſhame of the age. We firſt hear of him at *Oxford*, in the year 1226, as a fellow of a college; but he afterwards embraced the monaſtic ſtate, and lived a religious in the abby of *Weſtminſter*. He was beyond all compariſon the top-man of thoſe times; and might, perhaps, ſtand in competition with the greateſt that have appeared ſince. 'Tis wonderful, conſidering the igrorant age wherein he liv'd, how he came by ſuch a depth of knowledge, on all ſubjects. His treatiſes are compoſed with that elegancy, conciſeneſs, and ſtrength, and abound with ſuch juſt and exquiſite obſervations on nature, that, among the whole tribe of chemiſts, we don't know one that can pretend to contend with him. The reputation of his uncommon learning ſtill ſurvives in *England*. His cell is ſhewn at *Oxford* to this day; and there is a tradition, that it will fall, whenever a greater man than *Bacon* ſhall enter within it. 1226. *Friar* Bacon's *hiſtory*.

He wrote many treatiſes; amongſt which, ſuch as are yet extant, have beauties enough to make us ſenſible of the great loſs of the reſt. What relate to chemiſtry, are two ſmall pieces wrote at *Oxford*, which are now in print, and the manuſcripts to be ſeen in the public library of *Leiden*; having been carried thither among *Voſſius*'s manuſcripts from *England*. In *His writings.*

* *Albertus Magnus*, now known by upward of twenty volumes *in Folio*, is ſaid to have been firſt diſtinguiſhed by his dulneſs and ſtupidity; inſomuch that he became the common jeſt of his fellow-ſtudents. At length, quite tired out, he reſolved to ſcale the walls of the convent, and run away. In this attempt, the holy virgin appear'd to him on the wall, and there gave him that underſtanding and ability which have ſince render'd him ſo famous. Such is the origin of the 22 *folio* volumes.

these treatises he shews how imperfect metals may be ripen'd into perfect ones. He entirely adopts *Geber*'s notion, that mercury is the common basis of all metals, and sulphur the cement; and shews, that it is by a gradual depuration of the mercurial matter by sublimation, and the accession of a subtle sulphur, by fire, that nature makes her gold; and that if, during the process, any other third matter happen to intervene, beside the mercury and sulphur, some other baser metals will arise: so that if we could but imitate nature's method, for instance, of ripening lead; we might change it into gold.

*His dogma's.*

Several of *Bacon*'s operations we have compar'd with the modern experiments of Monsieur *Homberg*, made by direction of that curious prince the duke of *Orleans*; and can attest, that *Bacon* has described some of the very things which *Homberg* publishes as his own discoveries. Thus, for instance, *Bacon* teaches expresly, that if a pure sulphur be united with mercury, it will commence gold: on which very principle Mons. *Homberg* has made divers experiments for the production of gold, described in the *Memoires de l'Academ. Royale des Sciences* *.

His other physical writings shew no less genius, and force of mind. In a treatise, † *Of the secret works of nature*, he shews, that a person who was perfectly acquainted with the manner nature observes in her operations, would not only be able to rival, but to surpass nature herself. He has another piece, || *Of the nullity of magic*, wherein, with great sagacity and penetration, he shews how the notion first got footing, and how weak all pretensions thereto are. Admiration, the parent of magic, is the offspring of ignorance, begot upon a vitiated imagination: When weak minds perceive an effect, whose cause is hid far in the dark, they presently have recourse to a dæmon to solve the difficulty; it must be the effect of magical art, or the intervention of some supernatural power, that's plain. This popular refuge of ignorance the judicious author deservedly confutes, and shews there is no such thing as *magic*, unless by that word be meant

* M. *Homberg*, in his *Essai du souffre principe*, from two experiments, the one with mercury, (which exposed to a digesting heat, ceases to be fluid, gathers into a powder heavier than mercury, and at length acquires such a fixedness, as to remain red-hot twenty-four hours, without loss; tho' upon applying a naked fire, the whole flies off in fumes, only leaving a piece of hard metal, form'd of the mercury, behind;) the other with regulus of antimony, (which, being expos'd to the duke of *Orleans*'s great burning-glass, to calcine, gain'd $\frac{1}{10}$ part in weight;) concludes, that *light may be introduced into porous bodies, may there fix, and increase both their weight and bulk*: and the *light thus retain'd in mercury, becomes inseparable therefrom, in the most vehement fire; and even changes the form of the mercury into a malleable ductile metal, heavier than any other metal, except gold.* Mem. de l'Acad. an. 1705.

In another place the same author argues, that *gold consists principally of two kinds of matter,* viz. *mercury, or quick-silver, and a metallic sulphur*, (which, according to him, is no other than Light) *either of which, taken a-part, evaporates with the least heat; but, when join'd together into a metal, after the manner just mention'd, they lose their volatility, and become so fix'd, that the most intense fire of our laboratories cannot separate them.* Mem. de l'Acad. an. 1707.

† De secretis naturæ operibus.

|| De nullitate magiæ.

a knowledge of the properties of bodies, and the methods of nature; by a dextrous application, whereof many things may be produced more ſurprizing than all the magic in the world has ever yet effected.

Such was the ſcope and tendency of his writings. What reward he met withal, is abominable to ſay: the man who had thus overthrown the idle pretenſions of the believers in magic, was himſelf branded for a magician, excommunicated, and condemned to the flames: a fate which has been ſhared with him, in ſome meaſure, by the greateſt and moſt deſerving perſons of many ages, and for the nobleſt cauſes: witneſs *Gallileo*, *Hildebrand*, and *Vigilius*, for aſſerting the motion of the earth, the antipodes, *&c.* *His fate.*

This author's works are printed in 8° and 12°, under the title of, *Frater Rogerius Baco de ſecretis artis & naturæ*; but are very rarely to be met withal. From a repeated peruſal of them, we find, our friar was no ſtranger to many of the capital diſcoveries of the preſent, and paſt ages. *His diſcoveries.*

Gun-powder he certainly knew: thunder and lightning, he tells us, may be produced by art; for that ſulphur, nitre, and charcoal, which, when ſeparate, have no ſenſible effect, when mingled together in a due proportion, and cloſely confined, yield a horrible crack. A more preciſe deſcription of gun-powder cannot be given in words: and yet a jeſuit, *Barthol. Schwartz*, ſome ages after, has had the glory of the diſcovery. *Gun-powder known to him.*

He likewiſe mentions a ſort of inextinguiſhable fire, prepared by art: which ſhews, he was not unacquainted with phoſphorus. *And phoſphorus.*

And that he had a notion of the rarefaction of the air, and the ſtructure of an air-pump, is paſt contradiction. A chariot, he obſerves, might be framed on the principles of mechanics; which, being ſuſtain'd on very large globes ſpecifically lighter than air, would carry a man aloft through the atmoſphere. *Sturmius* has ſince taken notice of the project, and ſhewn how to put it in practice: four hollow ſpheres are to be provided, all exceedingly thin, yet firm enough to ſuſtain the preſſure of the air; and on theſe a chair, or chariot, to be placed: then, exhauſting the air out of the globes, they will be taken up aloft, with their burden; and the perſon mounted thereon letting the air gradually enter by means of a cock, may ſubſide at pleaſure. Indeed, 'twould be very difficult procuring ſuch ſpheres; but it were impoſſible, without ſuppoſing the gravity, preſſure, and elaſticity of the air: our author, therefore, in averring the thing feaſable, gives an indication of his knowing ſome things which paſs among us for late diſcoveries. *And the air-pump.*

There are many other curious ſpeculations in the noble author, which will raiſe the admiration of the reader; but none of them will affect him with ſo much wonder, as to ſee a perſon of the moſt ſublime merit fall a ſacrifice to the wanton zeal of credulous bigots.

Lully.

RAYMUND LULLY, or *Ramon Lull*, comes the next in order. He was born in the island of *Majorca* in the year 1225, of a family of the first distinction; tho' he did not assume his chemical character till toward the latter part of his life. The authors of that time speak of him as a person eminently versed in the peripatetic learning; and, indeed, a great many of his writings witness no less. He had the address to introduce a new kind of *transcendental* art, called, from him, the *Lullian* art; by virtue whereof, a man might dispute whole days upon any topic in nature, without understanding any thing of the matter in dispute. The drift of this doctrine was to dispose the several sorts of beings into divers climax's, or scales, to be run down in a descending progression. Thus, whatever were proposed to be talked on; they would say, first, it is a *Being*; and, consequently, *one*; *true*; *good:* then, every Being is either *created*, or *uncreated:* and every created Being is either *body*, or *spirit*, &c. But, at length, perceiving the vanity of his own art, he quitted this barren superfluity of words, and went over to the other extreme.

Lully's *art.*

Upon his applying himself to chemistry, he soon began to preach another sort of doctrine; insomuch, that, speaking of that art, he says it is only to be acquired by dint of experiment, and cannot be conveyed to the understanding by idle words, and sounds. He is the first author I can find who considers alchemy expresly with a view to the universal medicine: but after him it became a popular pursuit, and the libraries are full of writings in that vein.

*His writings.*

*Lully* himself, beside what he wrote in the scholastic way, has a good many volumes, wrote after his conversion: 'tis difficult to say how many; for it was a common practice with his disciples, and followers, to usher in their performances under their master's name. I have perused the best part of his works; and find them beyond all expectation, excellent: insomuch that I have been almost tempted to doubt whether they could be the work of that age. So full are they of the experiments and observations which occur in our later writers, that either the books must be supposititious, or the antient chemists must have been acquainted with a world of things which pass for the discoveries of modern practice. He gives very plain intimations of phosphorus, which he calls the *vestal fire*; the *Offa Helmontii*, &c. And yet it is certain he wrote 200 years before either *Helmont*, or my Lord *Bacon*.

*And discoveries.*

He travelled into *Mauritania*, where he is supposed to have first met with chemistry; and to have imbibed his principles of the art from the writings of *Geber:* which opinion is countenanced by the conformity observable between the two.

The *Spanish* authors ascribe the occasion of his journey to an amour: he was fallen in love, it seems, with a maid of that country, who obstinately refused his addresses. Upon enquiring into the reason, she shew'd him a cancer'd breast. *Lully*, like a generous gallant, immediately resolves on a voyage to *Mauritania*, where *Geber* had lived; to seek some relief for his mistress. He ended his days in *Africa*; where, having taken up the quality

lity of miſſionary, and preaching the goſpel among the infidels, he was ſtoned to death *.

ARNOLDUS DE VILLA NOVA, or *Arnaud de Ville Neuve*, a *Frenchman*, thus denominated from the place where he was born, *viz. Ville Neuve*; is by ſome ſuppoſed to have been *Lully*'s maſter; but others, with more probability, take him to have been his diſciple. *Arnoldus* flouriſh'd in the 13th century. He was the firſt phyſician of that time; and in that quality ſerved the then pope. His writings ſhew him an excellent chemiſt, and even deep in alchemy. *Van-Helmont*, a great admirer of *Arnaud*, attributes to him the firſt introducing of chemiſtry into medicine. Arnoldus de Villa Nova.

He wrote a great many pieces, which are collected together in a *folio* volume, under the title of, *Magiſtri de Villa-nova*; and eaſy enough to be had. At the end is a little treatiſe of alchemy, perfectly in the manner, and on the principles of *Geber* and *Lully*. He is every where a ſtrenuous advocate

* The hiſtory of this eminent adept is very much imbroil'd. Authors ſpeak of him very differently; and 'tis not eaſy, on the whole, to decide whether ever he were a chemiſt, or wrote at all on the ſubject, or not. *Vincent. Mutius*, who writes the hiſtory of *Majorca*, ſhews him in a very different light: *Lully*'s father, ſays he, was deſcended of a noble family; and his mother, of the houſe of the counts *d'Eril*. He was born in 1235. His firſt inclinations led him to ſtudy, which he afterwards quitted to follow arms. In this profeſſion he had leiſure for love, and entertain'd a paſſion for a maid, named *Eleonora*. One day, as he was viewing her with languiſhing eyes, ſhe laid bare her boſom, and ſhew'd her lover a cancer that had conſumed her breaſts. *Lully*, ſtruck ſpeechleſs at the ſight, immediately ſequeſter'd himſelf to ſolitude and anxiety. In the exceſs of his deſpair, a crucifix appear'd to him; which, inſpiring new courage, ſet him above the concerns of the world. The remainder of his life, therefore, he devotes to penance; and, among other pious exerciſes, applies himſelf to the converſion of infidels: with a view to which, he learn'd *Arabic* at thirty years of age. At his ſollicitation, *James* king of *Arragon* founded a ſeminary in *Majorca*, for the education of miſſionaries. After which, he travel'd thro' *France*, *Germany*, and *England*; and was at laſt put to death in *Africa* for preaching chriſtianity.

Now in all this relation, what have we that looks any thing like chemiſtry, or the philoſopher's ſtone? *Mutius* is even expreſs, that that good man, wholly intent upon religion, never applied himſelf thereto: and yet we have divers accounts in hiſtory of his making gold. Among other authorities, *Gregory* of *Tholouſe* furniſhes one: "*Lully*," ſays that author, "offered king *Edward* III. of "*England*, a ſupply of ſix millions to make "war againſt the infidels." To which may be added another from *Rob. Conſtantine*: "I have made enquiry, and find, that "*Lully* actually perform'd, what his Books "pretend he did, in *England*; and that he "made real gold in the tower of *London* by "the king's order." What diſcredits the relation and the hiſtorical writings whereon 'tis chiefly founded, is, that king *Edward* was only three years old, when *Lully* died: tho' this is not the only inconſiſtency; for in his books, he is ſaid to have made experiments at *Milan* in the year 1335; when 'tis certain he died in 1315.

*Borrichius*, however, will have the teſtimonies above-mentioned to be authentic; and fathers the faults in chronology on the copiſts. Be this as it will: beſide manuſcripts, the following printed pieces bear *Lully*'s name; *viz. The theory of the philoſopher's-ſtone: The practice: The tranſmutation of the ſoul: The codicil: The vade mecum: The book of experiments: The explanation of his teſtament: The abridgments, or accuſations*: and, *The power of riches*.

for an universal medicine; and says a deal to shew that there is such a thing in nature *.

Johannes de Rupe Scissa.

JOHANNES DE RUPE SCISSA comes next in turn. He was a *Franciscan* fryar, and flourish'd about the year 1380. He is a voluminous author; but his writings are of great weight and importance. Beside his theological pieces, he wrote many chemical ones; and had wrote more, as having a strong chemical taste, but that the good man, like his great predecessor *Bacon*, was accused of magic, and thrown into prison; where he pined and died away of grief: and by such means was prevented the discovering a great many secrets of nature, which he was become master of. He is held the patriarch of the chemists. His works are easy to be procured.

Ripley.

GEORGE RIPLEY, an *Englishman* by nation; and by profession a canon, or monk of *Britlingthon*, succeeds. His writings are all very good in their kind, being wrote exactly in *Bacon's* manner, only more allegorical. As he was no physician, he does not meddle with any thing of the preparations of that kind; but treats much of the *cure* of metals, which, in his language, is the purification and maturation thereof. He pursued *Geber's* and *Bacon's* principles very religiously; and maintain'd, for instance, with new evidence, that mercury is the universal matter of all metals; that this, set over the fire with the purest sulphur, will become gold; but that if either of them be *sick* or *leprous*, that is, infected with any impurity, instead of gold, some other metal will be produced. He adds, that as mercury and sulphur are sufficient for the making of all metals; so, of these, may an universal medicine, or metal, be produced, for curing of all the sick; which some, mistakenly, understood of an universal metal, efficacious in all diseases of the human body.

*His dogma's.*

Jo. *and* If. Hollandus.

JOHN and ISAAC HOLLANDUS, two brothers, come next. 'Tis not easy to say what countrymen they were; whether *Englishmen*, or, as their name may seem to import, *Hollanders*: we have in our keeping two manuscript copies of their works; one in the *English*, and the other *Low-Dutch* language: tho' we rather incline to think the *Dutch* the original, and the *English* a translation †.

They were both of them persons of great parts and ingenuity, and wrote on the dry topics of chemistry, with all the copious eloquence of orators. They seem to have lived in the 13th century; but this is not assured. The whole art of *enamelling* is their invention; as is also that of *colouring glass*, and *precious stones*, by application of thin metal plates thereon.

*Their inventions.*

* *Arnoldus* is mention'd by other authors, as physician to *Frederic* king of *Arragon*, and afterwards *Sicily*; and to have been occasionally sent by that prince to pope *Clement*, who was then sick: but he perish'd by shipwreck on the voyage, in the year 1310. *Nouv. Cours de Chymie. Jo. And. Ictus* relates his performing several transmutations at the court of *Rome*. The titles of his several pieces are, *The rosary of* Arnoldus: *Flower of flowers*; *Chemical letter to the king of* Naples: *The new light*: *The questions of Pope* Boniface VIII. *with answers thereto*: And, *The mirror of alchemy*.

† The *Dutch* manuscript is here and there interpolated with *English*.

Their

Their writings are in the form of proceſſes; and they deſcribe all the operations, to the moſt minute circumſtances. The treatiſe of *enamelling* is eſteem'd the greateſt, and moſt finiſh'd part of their works; whatever relates to the fuſion, ſeparation, and preparation of metals is here deliver'd. They write excellently of *diſtillation*, *fermentation*, *putrefaction*, and their effects; and ſeem to have underſtood, at leaſt as much of theſe matters, as any of the moderns have done. They publiſh'd a ſmall *treatiſe of the philoſopher's-ſtone*; which, they hold, may be prepared from any body in nature. They deſcribe ways of producing it from lead, blood, ſulphur and mercury, and other matters. They furniſh a great many experiments on human blood; which *Van Helmont* and Mr. *Boyle* have ſince taken for new diſcoveries. I have a very large work in *folio* under their name, of the conſtruction of *chemical furnaces and inſtruments*. *Dogma's.*

Their writings were firſt publiſh'd in ſeparate volumes, which are as eaſily purchaſed as they are worthy of peruſal, for the ſake of ſome valuable ſecrets contain'd therein, which may pave the way for the greateſt diſcoveries.

All the authors hitherto rehears'd have been confined to the *metallurgia*; or at leaſt to ſome one or two peculiar bodies: Metals, for inſtance, glaſs, and precious ſtones were thus long the whole field and ſubject of chemiſtry, about which all the chemiſts from *Zozimus* to *Hollandus* were employ'd. We ſhall only here take occaſion to add, in the general, that it is no valid objection againſt the art or veracity of any of 'em, that in ſome places we don't conceive or underſtand 'em; ſince, wherever we do, there they always ſpeak true: This is certainly a ſtrong preſumption in favour of the truth of things, which ſurpaſs our comprehenſion.

We now proceed to the ſecond order, or claſs of chemiſts: *viz.* Thoſe who have cultivated the art with a view to Medicine; whether in order to a diſcovery of an univerſal remedy for all Diſeaſes, or of particular ones in the ordinary way of phyſic. *Authors in the medicinal part of chemiſtry.*

BASIL VALENTINE is the firſt in this liſt: But who he was, or whence he came, is but little known; for the name is apparently fictitious: He is commonly ſaid to have been a *Benedictine* monk, of a Monaſtery at *Erphurt*, which is the quality he aſſumes in his writings; but there is no trace, or memory of ſuch a perſon at *Erphurt*; nor was there ever any *Benedictine* monaſtery there; whence, it looks more probable he was ſome great man, who, according to the cuſtom of that age, choſe to veil himſelf under this appellation. *Helmont*, who took a deal of pains in the enquiry, ſhews he was prior to *Paracelſus* by a hundred years; and that he lived in 1415. Some fix his birth to the year 1394. Baſil Valentine.

His writings are much commended, and much ſought; tho' there are ſome ſpurious pieces tack'd to 'em. He wrote all in *High Dutch*, and 'tis but few of his pieces that have been tranſlated into *Latin*. In matters of experiments he may be depended on for his exactneſs, and veracity: His ſtyle is clean, open, and pure; except when he treats of his arcanums, and particularly of the philoſopher's-ſtone; where he is as cloudy as the reſt. *Character of his writings.*

By

*The first that applied chemistry to medicine.* By what appears, it was he who first applied chemistry to medicine; for, after every preparation, he never fails to give some medicinal use thereof. He owns that he practised physic himself; and had prescribed a *Lithonthriptic* to the great chancellor of the empire; whereby a stone in his bladder was actually dissolved.

One blemish in his character, which indeed runs thro' the whole tribe of his followers, is, that he is too liberal in the uses, and virtues of his preparations. Thus in his *triumphal chariot of Antimony*; a mineral, which we are to observe, was the basis of almost all his medicines; we meet with nothing but grand, catholic, universal remedies.

One thing certainly redounds much to his glory: *viz.* That his stock of chemical knowledge has served abundance of his Successors to spend on. *His dogma's and discoveries.* It was he, who first broach'd the doctrine of the three chemical principles, *Salt*, *Sulphur*, and *Mercury*, which *Paracelsus* afterwards appropriated; and it might be shewn, that both *Paracelsus*, and *Helmont*, and many others of modern fame, owe a great part of what is most valuable in 'em, to this author: So that it is not without reason, that he is judg'd the father of the modern chemists, and the founder of the chemical pharmacy.

In his *currus triumphalis Antimonii* we meet with all the experiments and preparations, which the younger *Lemery* has in his late *French* treatise *de l'Antimoine*; and yet *Lemery* puts 'em all off, as if they were new, and his own.

*Van Helmont* had writ much about the alcahest, or universal menstruum, and *Zwelfer* pretends to have known his secret: He describes it as a preparation of vinegar and copper-rust distill'd, till the copper quite disappears. But *Otto Tachenius* shews, that *Zwelfer* borrow'd the whole process from a book of *Valentine*'s, entitled *Standgeist*; where, indeed it is described in terms plain enough.

So the *sal volatile oleosum*, which *Sylvius de la Boe* has long had the credit of; and many other secrets which make a figure in the modern authors, are really originally derived from *Basil Valentine*.

*Paracelsus.* PARACELSUS comes next on the stage; a great, anomalous, unaccountable fellow; whose history will have all the air of paradox. He reform'd and alter'd the face of medicine, and turn'd it altogether into the vein of chemistry; being the first of all mankind, who, of a profess'd chemist, was made a public Professor of medicine in an university. Never did any person bear such different, inconsistent characters as the author we are now about to treat of: amid so much diversity, it will require no small degree of attention and address, to keep the truth in view, and pursue it without deviating into any of the tracks of fable and fiction. To hear the generality of chemists talk, he was nothing less than a God; nay, 'tis a tradition, which I find several people believe, that he is not dead, but still lives in his tomb; whither he retired, weary of the vices and follies of mankind. And yet others represent him as one of the most vile, flagitious, and worthless of the race of men.

To

To aſcertain ſomewhat of the character of this memorable perſon, we have conſulted all the writers on both ſides the queſtion; and will give you his ſtory, not as 'tis drawn by his profeſs'd Devotees, the *Paracelſiſts*; nor yet from thoſe, who determinately vilify him at all adventures, as *Eraſtus*, *Theophilus*, *&c.* But, principally, as deliver'd by *J. Oporinus*, *Greek* profeſſor in the ſame univerſity with *Paracelſus*; by *J. Crato a Krafthen*, an illuſtrious phyſician of that time, who converſed with *Paracelſus*, and whoſe writings have all the marks of candour and exactneſs; and by *Van Helmont*, who travel'd into *Germany*, on purpoſe to enquire into the matter, and ſatisfy himſelf of the truth of the ſtories related of our philoſopher: Tho' as to this laſt author, we ſhall be a little on our guard; as he appears ſtrongly inclined in favour of his maſter, and has publickly declared *Paracelſus* the *prince of phyſicians, and philoſophers by fire.*—We now come to the point.

PHILIP AUREOLUS THEOPHRASTUS PARACELSUS BOMBAST DE HOENHEYM was born, as he himſelf writes, in the year 1494, in a village in *Switzerland*, call'd *Hoenheym* (*q. d. ab alto nido*) two miles diſtant from *Zurich*. His father was a natural ſon of a great maſter of the *Teutonic* order, and had been brought up to medicine; which he practiſed accordingly, in that obſcure corner. He was, it ſeems, maſter of an excellent, and copious library; and is ſaid to have become eminent in his art; ſo that *Paracelſus* always ſpeaks of him with the higheſt deference, and calls him *laudatiſſimus medicus in eo vico.* Of ſuch a father did *Paracelſus* receive his firſt diſcipline.

After a little courſe of ſtudy at home, he was committed to the care of *Trithemius*, the celebrated abbot of *Spanheim*, who had the character of an adept himſelf, and wrote of the *Cabbala*: being by many reputed a magician. Here he chiefly learnt language and letters; after which, he was removed to *Sigiſ. Fuggerius*, to learn medicine, chirurgery, and chemiſtry. All theſe his maſters, and eſpecially the laſt, *Paracelſus* ever ſpeaks of with great veneration: So that he was not altogether ſo rude and unpoliſh'd as is commonly imagined. Thus much we learn from his own writings; and eſpecially the preface to his *leſſer chirurgery*, where he defends himſelf againſt his accuſers.

At 20 years of age, he undertook a journey throughout *Germany*, and *Hungary*; viſiting all the mines of principal note, and contracting an acquaintance with the miners and workmen; by which means he learnt every thing relating to metals, and the art thereof. In this inquiry he ſhew'd an uncommon aſſiduity, and reſolution: He gives us a frightful account of the many dangers he had run from earthquakes, falls of ſtones, floods of water, cataracts, exhalations, damps, heat, hunger, and thirſt; and every where takes occaſion to inſiſt on the value of an art acquired on ſuch hard terms.

The ſame inclination carried him as far as *Muſcovy*; where, as he was in queſt of mines, near the frontiers of *Tartary* he was taken priſoner by that people, and carried before the great *Cham*: during his captivity there, he learnt divers ſecrets; Till, upon the *Cham's* ſending an embaſſy to the Grand

Grand Signior with his own ſon at the head of it, *Paracelſus* was ſent along with him in quality of companion. On this occaſion he came to *Conſtantinople*, in the 28th year of his age; and was there taught the ſecret of the philoſopher's-ſtone, by a generous *Arab*, who made him this noble preſent, as he calls it, *Azoth.* This incident we have from *Helmont* only; for *Paracelſus* himſelf, who is ample enough on his other travels, ſays nothing of his captivity.

At his return from *Turky*, he practiſed as a chirurgeon in the imperial army, and perform'd many very notable cures therein. Indeed it can't be denied but he was excellent in that art; of which his *great chirurgery* printed in *folio*, will be a ſtanding monument. At his return to his native country, he aſſumed the title of *utriuſque medicinæ doctor*; or doctor both of internal, and external medicine or chirurgery; and grew famous in both; performing things far beyond what the common practice of that time could pretend to. And no wonder: for medicine was then in a poor condition: The practice, and the very language was all *Galenical*, and *Arabic*. Nothing was inculcated but *Ariſtotle*, *Galen*, and the *Arabs*; *Hippocrates* was not read: Nay, there was no edition of his writings; and ſcarce was he ever mention'd. Their theory conſiſted in the knowledge of the four degrees, the temperaments, *&c.* and their whole practice was confined to venæſection, purgation, vomiting, clyſmata, *&c.*

*Improves on the medicinal practice of thoſe times.*

Now in this age a new diſeaſe had broke out, and ſpread itſelf over *Europe*; *viz.* the venereal diſeaſe: The common *Galenic* remedies had here proved abſolutely ineffectual: Bleeding, purging, and cleanſing medicines were vain; and the phyſicians were at their wit's end. *Jac. Carpus*, a celebrated anatomiſt and chirurgeon at *Boulogne*, had alone been maſter of the cure; which was by mercury adminiſtred to raiſe a Salivation: He had attain'd to it in his travels thro' *Spain* and *Italy*, and practiſed it for ſome years, and with ſuch ſucceſs and applauſe, that it is incredible what immenſe riches this one *noſtrum* had brought him in: he owns himſelf, that he did not know the end of his own wealth; For the merchants, governors, commanders, *&c.* who had brought that filthy diſeaſe from *America*, were content to give him what ſums he pleas'd to free 'em from it.

*Attains to the uſe of mercury.*

*Paracelſus*, about this time, having likewiſe learnt the properties of mercury; and, as 'tis probable, from *Carpus* too, undertook the ſame cure, but in a different manner: For whereas *Carpus* did all by ſalivation; *Paracelſus*, making up his preparations in pills, attain'd his ends in a gentler manner. By the ſame medicine he tells us, he cured the itch, lepra, ulcers, *Neapolitan* diſeaſe, and even gout; all which were incurable on the foot of the popular practice: And thus was a baſis laid for all his future fame.

*Made profeſſor at Baſil.*

*Paracelſus* thus furniſh'd with arts, and arrived at a pitch of eminence beyond any of his brothers in the profeſſion, was invited by the curators of the univerſity of *Baſil* to the chair of profeſſor of medicine and philoſophy in that univerſity. The art of printing was now a new thing; the taſte for learning and arts was warm; and the magiſtracy of *Baſil* were very induſtrious

trious

trious in procuring professors of reputation from all parts. They had already got *Desid. Erasmus*; professor of theology; and *J. Oporinus*, professor of the *Greek* tongue: and now, in 1527, *Paracelsus* was associated; in the 33d year of his age.

Upon his first entrance on that province, being to make a public speech before the university, he posted up a very elegant advertisement over the doors, inviting every body to his doctrine. At his first lecture he procured a fire to be brought in a brazen vessel, into the middle of the school; where, after casting in sulphur and nitre, in a solemn manner, he burnt the writings of *Galen*, and *Avicenna*: alledging, that he had held a dispute with them in the gates of hell, and had fairly routed and overcome them. And hence he proclaimed, that the physicians should all follow him; and no longer call themselves *Galenists*, but *Paracelsists* *. *Burns the writings of* Galen *and* Avicenna.

While he was here professor, he read his books, *de Tartaro*, *de Gradibus*, and *de Compositionibus*, in public lectures; to which he added a *commentary* on the book *de Gradibus*: all these he afterwards printed at *Basil* for the use of his disciples; so that these must be allowed for genuine writings. About the same time he wrote *de Calculo*; which performance *Helmont* speaks of with great approbation. *His lectures.*

Notwithstanding his being professor in so learned an university, he understood but little *Latin*; his long travels, and application to business, and disuse of the language, had very much unqualify'd him for writing, or speaking therein: and his natural warmth, and arrogancy, render'd him very unfit for teaching at all. Hence, tho' his auditors and disciples were at first very numerous, they fell off, and left him to preach jargon to the walls. In the mean time, he abandoned himself to drinking; and, by degrees, commenced such a thorough sot, that *Oporinus*, who lived with him, and was always at his elbow, assures us he was never sober; but kept tippling on from morning to night, and from night to morning, in a continued round. By such means he soon became weary of his professorship; and, after three years continuance therein, relinquished it: pretending, that no language beside the *German* was proper to reveal the mysteries of chemistry in. *His pupils deserting him, turns sot.*

After this, he betook himself again to his itinerant life; spending his whole time in travelling, and drinking, and living altogether in taverns, and inns, continually flush'd, and loaden with liquor; and yet working many notable cures in his way. In this sordid manner did he pass four years, *viz.* from the 43d, to the 47th year of his life; when he died, as he lived, in an inn, at *Saltzburg*, at the sign of the white horse, on a bench, in the chimney-corner. *Oporinus* relates, that after he had put on any new garment, it never came off his back, till it was wore to rags. He adds, that notwithstanding his excess in point of drinking, he was never in the *His death.*

* "Know, physicians," says he, "my cap has more learning in it than all your heads; my beard has more experience than whole academies of you: *Greeks*, *Latins*, *French*, *Italians*; I will be your king."



least

leaſt addicted to venery. But there was a reaſon for it: it ſeems, when he was a child, being neglected by his nurſe, a hog fell in his way, which bit off his teſticles, and ſo made an eunuch of him. Accordingly, in his writings, he omits no occaſion of railing againſt the women.

Such was the life of *Paracelſus*; ſuch was the immortal man, who, ſick of life, retired into a corner of the world; and there ſupports himſelf with his own *Quinteſſentia Vitæ*. We now proceed to his books; and his pretenſions to the grand *arcana* of alchemy.

*His writings.* In his life-time, we have already obſerved, he only publiſhed three, or four books. But after his death, he grew prodigiouſly voluminous; ſcarce a year paſſing, but one book or other was publiſhed under his name; ſaid to be found in ſome old wall, ceiling, or the like. All the works father'd on him were firſt publiſhed together at *Strasbourg* in the year 1603, in three volumes *in folio*; and again in 1616. Theſe editions are both in *High-Dutch*; on which account they are preferable to the reſt, as the books were all originally compoſed in that language. But in both theſe editions, the 10th book, *de Archidoxis*, is wanting; which is, as it were, the key of all the reſt. In the year 1658, all the three volumes were publiſhed at *Geneva*, tranſlated into *Latin*; with the addition of the 10th book, ſo much wanted in the former.

*J. Oporinus*, that excellent profeſſor and printer abovemention'd, who conſtantly attended *Paracelſus* for three years as his menial ſervant, in expectation of learning ſome of his ſecrets; who publiſh'd the works of *Veſalius*; and is ſuppoſed to have put them in that elegant language wherein they now appear: this *Oporinus*, in an epiſtle to *Monavius*, concerning the life of *Paracelſus*, profeſſes himſelf ſurprized to find ſo many works of his maſter; for that in all the time he was with him, he never wrote a word himſelf, nor ever took pen in hand: but that as he ſpent all his time among porters and carmen, and was eternally drunk, he would ſometimes come reeling home, and, brandiſhing his drawn ſword, force *Oporinus* to write what he dictated. But this was but little. However, *Oporinus* uſed to wonder how ſuch coherent words, and diſcourſe, which might even become the wiſeſt perſons, ſhould come from the mouth of a drunken man.

*Many of them ſuppoſititious.* 'Tis more than probable, then, that the bulk of the pieces publiſhed under his name, are not his; but that the other chemiſts, his followers, choſe to uſher in their performances under the ſanction of his name. In effect, they are ſo many, and ſo different from each other, that 'tis next to impoſſible they ſhould all come from the ſame hand. And yet, beſide the three books which he lectured in public, there are ſome others that ſeem to have good pretenſions to be genuine: ſuch is that *de Peſte*, wrote for the ſake of his hoſts in the eaſt, and about *Conſtantinople*, from whom he had receiv'd a deal of kindneſſes, and whom he had then promiſed a remedy againſt the plague: that *de Mineralibus*: that *de vita longa*: and the *Archidoxa Medicinæ*, which was publiſhed by *Bodenſteyn*, while *Paracelſus* was living, or at leaſt ſoon after his death.

This

This work is call'd *Archidoxa Medicinæ*, as containing the principal rules and maxims of the art. Nine books hereof were publiſhed at firſt: and the author in the prolegomena to them ſpeaks thus: *I intended to have publiſhed my ten books of* Archidoxa; *but finding mankind unworthy of ſuch a treaſure, as the tenth, I keep it cloſe in my* occiput; *and reſolve never to bring it thence, till you have all abjured* Ariſtotle, Avicenna, *and* Galen, *and have ſwore allegiance to* Paracelſus *alone.*

However, the book did at length get abroad; tho' by what means is not known: it is confeſſedly a glorious piece, and may be ranked among the principal productions in the way of chemiſtry, that have ever appear'd. Whether or no it be *Paracelſus*'s, we will not affirm; but there is one thing ſpeaks in its behalf, *viz.* its containing a great many things which have been ſince trump'd up for great *Noſtrums*; and *Van Helmont*'s lithonthriptic, and alcaheſt, are apparently taken hence. The following paſſage of *Helmont* has occaſion'd me much ſpeculation: *To diſtil the volatile ſpirit of ſea-ſalt, in order to diſſolve the ſtone in the bladder; digeſt ſea-ſalt for a month with juice of horſe-radiſh; and then diſtil the whole: what riſes, is the ſpirit of the ſalt; of ſingular efficacy in diſſolving the ſtone either in the bladder, or reins.* I was always at a loſs how *Helmont* came to know that ſea-ſalt would ferment with radiſh-juice; there being no hint of the thing in any of his other writings: but my ſurprize was over upon reading the proceſs in expreſs terms in the 10th book of *Archidoxa.* So is the whole book, *Of the alcaheſt*, moſt apparently taken from the ſame.

Among the genuine writings of *Paracelſus*, are likewiſe reckon'd that *De ortu rerum naturalium*, *De transformatione rerum naturalium*, and *De vita rerum naturalium.* The reſt are ſpurious, or very dubious at beſt; particularly the theological works.

It remains, that we ſift his merits as to medicine, and alchemy: enquire what wonders he wrought therein; and on what ground his pretenſions to the philoſopher's ſtone, and univerſal remedy, ſtand.

This, then, muſt be confeſs'd, that an arrogant, aſſuming air, infected all his writings, as well as his actions. It was familiar with him to promiſe mighty things with compleat aſſurance; upon ſlender, inadequate grounds. Could there be a greater inſtance of the man's foible in this reſpect, than his undertaking, by the mere uſe of his *Elixir Proprietatis*, (a preparation of aloes, myrrh, and ſaffron) to prolong a man's life to the age of *Methuſaleh*; and to deliberate with himſelf to what period he ſhould protract his own? It argues his truſting to imagination more than experiment: for, as he died a young man himſelf; 'tis certain he could not have experiments ſufficient to warrant any ſuch thing; nor did he ſpeak of his knowledge, as a phyſician ought to do, but purely of his caprice.

*His pretenſions to an univerſal medicine.*

We know not how it is, but the common body of chemiſts both of his and our times have complimented *Paracelſus* with the knowledge of the univerſal remedy; and he himſelf is at the head of the opinion: he ſwears by his own ſoul, and calls every God in heaven to witneſs, that with one ſingle remedy prepared from metals, he was able to cure all diſeaſes, be

they ſtone, gout, cancer, or what they will: To hand down which opinion to poſterity in the moſt ſolemn manner, it is engraven on his monument in the outer wall of the church of *Saltzburg*. But for all this aſſurance, a man may venture to withold his aſſent: His own hiſtory affords no great proofs of the thing; nor have we any competent teſtimonies of other writers. *Helmont*, who knew as much of *Paracelſus* as any man living, does not believe a word of it: That author is always commending him, but warns us not to truſt to him; adding, that his writings are full of babble.

*Crato*, in his epiſtle to *Monavius*, relates, that "upon the rumour of his "great skill at the emperor's court, he was ſent for to cure the great "chancellor, then laid up of the gout. *Paracelſus* undertook the cure; "and promis'd a very ſpeedy recovery, on condition all the other phyſicians "ſhould be ſet aſide. But after ſeveral weeks ſpent in vain, the patient "rather going backwards every day; finding the moſt powerful of his "remedies ineffectual, he ſlipt privately away, and cou'd never by any "words or promiſes be brought to court again *." *Borrichius*, who ſo warmly maintains him a maſter of all the arcana aim'd at by alchemiſts, would find ſomewhat to do, to give a reaſon for his failure in this inſtance: again, *Crato* adds, that being at a conſultation with *Paracelſus*, *Crato* ask'd him why he cough'd, when he had ſo noble a remedy in his hands? to which *Paracelſus* anſwer'd, *I cou'd ſoon cure myſelf, were it not for this*; at the ſame time taking up a cup of wine.

But what effectually overthrows his pretenſions to ſuch a remedy, is his own dying at an immature age. When at *Saltzburg*, finding his days near a period, he ſent for a notary to make his will; which is ſtill preſerv'd by the magiſtrates of the place. The ſame notary atteſts, that he found *Paracelſus* on his legs, and perfectly ſenſible; only very weak and languiſhing: If he had any notion of an univerſal remedy, this certainly was the time for it. As to what is objected from his epitaph, it will have no great weight; in theſe monumental inſcriptions, we all know how little regard is had to hiſtorical truth.

*His real merits.* The great fame and ſucceſs of the man, which with ſome paſſes as an argument of his being poſſeſs'd of the ſecret; is eaſily accounted for from other principles. 'Tis certain he was acquainted with the uſe and virtues of *opium*, which the *Galeniſts* of thoſe times all rejected as cold in the fourth degree: *Oporinus* relates that he made up a ſort of little pills of the colour, figure, and ſize of mice-turds; which were nothing but *opium*. Theſe he call'd by a barbarous ſort of name, his *laudanum*, *q. d.* laudable medicine; he always carried them with him, and preſcribed 'em in dyſſenteries and all caſes attended with intenſe pains, anxieties, deliriums, and obſtinate wakings. But to be alone poſſeſs'd of the uſe of ſo extraordinary and noble a medicament as *opium*, were enough of itſelf to have render'd him ſufficiently famous.

* The ſame *Crato* tells us, that *Paracelſus* being ſent for to the emperor, who was dangerouſly ill, he took a pill out of the pummel of his ſword, which ſucceeded ſo well, that the emperor went a-hunting the next day.

Another

Another grand remedy which *Paracelſus* had to himſelf, was *Turbith Mineral.* This is firſt mention'd in his *Clein Spital Boeck*, or *Chirurgia minor*; where he gives us the preparation. "Take, ſays he, mercury, mix it up with "thrice the quantity of oil of vitriol; precipitate, and waſh it with water, "and you will have a yellowiſh powder; diſtil it with ſpirit of wine, and "adminiſter it to the quantity of 8 grains; it will cure all the diſeaſes a- "bove-mentioned." This is the very *Turbith* which the modern practitioners find of ſo much efficacy in the venereal, and almoſt all chronical and cutaneous diſeaſes, where violent vomitories are required: Indeed the doſe here mention'd is too large, but he durſt try any thing. *Oporinus* relates, that all the time he was with *Paracelſus*, he ſpent his ſober hours in making his *Emplaſtrum opodeldoch*, and preparing *Turbith*; nor does he make mention of any other remedies.

*The ground of his fame.*

By this time we have *data* enough to account for *Paracelſus*'s mighty fame. 1°, In that he was well skill'd in chirurgery, and practiſed it with great ſucceſs. 2°, That he underſtood the common practice of phyſic as well as his cotemporaries. 3°, That he was alone maſter of the powers, preparations, uſes, &c. of metals. 4°, That he had the uſe of *opium* to himſelf, and wrought wonderful cures thereby. And 5°, That he was well acquainted with the virtues of mercury, in an age when no other perſon but *Carpus* knew any thing of the matter. Theſe five concurring circumſtance take in his whole merit; and were the matter of all his glory: the reſt was empty ſmoke, and idle oſtentation.

*His pretenſions to the philoſopher's-ſtone.*

We have but little to ſay as to the philoſopher's-ſtone, which his followers put him in poſſeſſion of; 'tis certain he was at firſt very poor, and grew at length immenſely rich. *Oporinus* ſays, he has frequently wonder'd to ſee him one day without a farthing in his pocket, and the next day full of money; and that he never took any thing with him, when he went abroad. He adds, that he would often borrow money of his companions, the carmen and porters; and pay it again in 24 hours, with extravagant intereſt: and yet from what fund, no body knew. In the *theatrum alchemiæ* he mentions a treaſure hid under a certain tree, *quem tu Papilio, nec tu Carole unquam poteſtis æquare*; and from ſuch grounds is he ſuppoſed to have had the art of making gold. But, why have recourſe to ſo violent a machine, when a leſſer will do? 'Twas hard if ſuch noble noſtrums as he poſſeſs'd, would not ſubſiſt one man; when we find what comfortable livelihoods are now got by every pitiful pretenſion to an *arcanum.*

'Tis certain *Paracelſus* wrought abundance of great cures, and in the ſame way with *Carpus*, whoſe wealth has already been mention'd; and it appears he knew how to ask his fees: Witneſs the poor *Canon*'s caſe, who being ſeverely handled by the venereal diſeaſe, *Paracelſus* refuſed to undertake his cure, but on promiſe of a huge reward; the cure was accordingly wrought by a ſalivation; but the *Canon* finding how ſoon 'twas done, and with how few medicines, refuſed to give the ſtipulated reward. *Paracelſus*, hereupon, in a rage brings him before a court of juſtice; with loud outcries demands the judges to order the payment; and upon their

declining

declining it, purfued 'em with all the reproaches and railing, his fpleen could fuggeft. A man thus provided, one would think, might make a fhift in the world, without the philofopher's-ftone to help him out.

VAN HELMONT, the greateft and moft experienced of all the chemifts that have yet appear'd, fucceeds *Paracelfus*; 'twas he put the finifhing hand to what his predeceffor had but begun: *viz.* the introducing of chemiftry into medicine. He was originally, and by profeffion a phyfician; but wrought fuch a change in that art upon his taking to chemiftry, that nothing at length could go down in *phyfic*, but what was thoroughly *chemical.*

The fate of chemiftry, and the idea we are to form thereof, has a confiderable connection with that of the life, writings, and pretenfions of this memorable perfon: So that they will deferve to be thoroughly difcufs'd. To prepare myfelf to give you the more fatisfaction on this head; befide perufing all his writings with great attention, I have made induftrious inquiry about *Bruffels*, *Wilword*, and *Bois le duc*, the places where he fpent the greateft part of his life; and have got intelligence which may guide us in forming a judgment of him.

*History of* Van Helmont.

JOHN BAPTISTA VAN or AB HELMONT, was born at *Bruffels*, in the year 1557, thirty-fix years after the death of *Paracelfus*. He was defcended of a noble family, which took its denomination from a little village call'd *Helmont*, in the neighbourhood and diftrict of *Sylva ducis*, or *Bois le duc.*

At three years of age he loft his father; and as he was the youngeft born of a numerous family, not having much fortune left him, he applied himfelf to his ftudies. At proper years he was fent to the univerfity of *Louvain*; where he ftudied mathematics, and particulary algebra, which he made great proficiency in, and became eminently verfed in all the doctrines thereof. He then applied himfelf to the Schools, *i. e.* to the difcipline of *Ariftotle* and *Galen*, which was the reigning ftudy at that time at *Louvain*; at length he turn'd himfelf to medicine, which he learnt under feveral profeffors, particularly *Fortunatus Vopifcus*, *Plempius*, *&c.* and with fuch fuccefs, that at feventeen years of age, he was thought qualified to teach phyfic; and, accordingly, was appointed *prælector* thereof, according to the cuftom of the regents, and profeffors of that age, who generally chofe the moft learned among their difciples, to give public lectures to the reft. Thus did *Helmont* give his lectures of medicine, tho' fome fay only of chirurgery; and fo far did he here go, till he was promoted to the degree of doctor in the faculty. This we learn from his own writings; and yet in other places he denies he ever was created doctor; but he is not there to be underftood in the ftricteft terms: For that he did take the degree, and in the year 1559, is certain; and there is a regifter thereof ftill extant among the acts of that univerfity. His reafon for fuppreffing the knowledge of his doctorate, was, in his own words, *ne imperiti homines dicerent fe peritum promoviffe, habuit enim imperitos profeffores*; left ignorant unskilful perfons, fuch as he efteem'd the profeffors, fhould have the credit of promoting one fo well skill'd as himfelf.

*His proficiency in the fchool learning.*

*Commences doctor of phyfic.*

While

While he was here, he aſſures us he read over *Galen* twice, and *Hippocrates*, and all the *Arabs*, and *Greeks*, once; and this before he arriv'd at twenty-two years of age: ſo that he had laid in an ample ſtock of the learning, and arts of thoſe days, e'er he came to chemiſtry.

Now that he had gone through his courſe of ſtudies, and was arrived at the doctorate; he enter'd upon the practice of phyſick: but his firſt ſucceſſes came vaſtly ſhort of his expectation. This put him ſtrangely out of humour with the art; which another incident, about the ſame time, help'd to confirm. It happen'd, thro' ſome extraordinary familiarity with a maid of quality, that he caught the itch: upon this, his brothers of the profeſſion were applied to, to help rid him of ſo filthy a diſeaſe. He told them what meaſures he had already taken; that he had open'd a vein, had taken ſcammony, &c. and they applauded every ſtep; ordering him, withal, a diætetic decoction. But all was in vain; the diſeaſe kept its hold; and the whole faculty was baffled. Hence, he began to be in doubt, whether phyſic had any foundation in nature.

*Fails in the practice of phyſic.*

*Begins to doubt the foundation of the art.*

Under this mortifying uncertainty, he reſolv'd to ſell all his books, and diſpoſe of his effects; and travel'd about from place to place, to inform himſelf better; and learn what there was further to be known. He had here time for reflection, and began to think it a judgment on him, for running ſo eagerly after medicine; contrary to all the intreaties, and remonſtrances of his friends, and relations. Thus unhappily did his days paſs, the ſpace of ten years; when, about the 33d year of his age, he accidentally met with a *Paracelſian* chemiſt. Upon a converſation between them, the chemiſt aver'd he could do more with one or two of his chemical preparations, than the *Galeniſts* with all their ſtock; and that *Paracelſus* had done more than all the other phyſicians put together For a proof, he cured him of his itch by means of ſulphur; and ſhew'd him ſome other experiments.

The abandon'd phyſician began now to take heart again: this new light ſoon alter'd the courſe of his thoughts; and to chemiſtry he falls with all his might. In order to this, he retir'd to *Wilword*; where he lived a long time, in great eaſe, and tranquillity, out of all road of his friends, and acquaintance, wholly taken up in chemical operations, night and day.

*Takes to chemiſtry.*

Here, with unwearied labour, he examined the whole tribe of bodies, both foſſile, vegetable, and animal, by the light of chemiſtry; and thus, firſt furniſh'd a new body, or courſe of chemical knowledge. Here it was he made thoſe noble experiments, and diſcoveries, of oil of ſulphur *per campan.* the *Laudanum Paracelſ. Acidum hoſtile*, &c. ſpirit of hart's-horn, ſpirit of human blood, *ſal volatil. oleoſ.* &c.

*His experiments and diſcoveries.*

To look back a little: he had of many years been a maſter of the philoſophy of that age, which conſiſted wholly in words, without facts, or experiments; he was now become deep in chemiſtry, which is all experiment, and no ſound; and he had before attain'd the *Galenical* medicine, and that of the *Arabs*, which turn wholly on the four elements, four humours,

mours, and four qualities, and uses few other remedies beside phlebotomy, purging, and *Cantharides*.

*Reduces all medicine to chemistry.* Now, a man of his genius, and views, seeing so many more powerful remedies produced by chemistry; naturally enough began to imagine, that all might be true, *Paracelsus* had advanced; and thus took the contrary byass, run counter in every thing to the *Galenic* school, banish'd every thing of that kind out of medicine, and reduced the whole art to principles of chemistry. He tells us he had long observ'd the impertinence of the school-doctrine, both in philosophy and medicine; and that it was only fit for talk, not action: in which sentiment he was follow'd by the great lord *Verulam*, who every-where stiles the peripatetic school *Logodædala*, as talking a deal about the nature of things; but handling nothing.

*His writings.* With such views he began to write: his first production was of * *spaw-waters*, printed at *Liege* in 1624, and procured him a world of esteem. There are abundance of good things in it, and but little of that opinionativeness, and boasting, which shew'd itself in his later works: he had it reprinted the same year at *Cologne*, with new experiments. In 1644 he published his second piece, *Of the humours* †, against the humourists; a third, *Of fevers* ||; and a fourth, *Of the stone* ††: which are all the books he published in his life-time.

Soon after the publication of the last, he died, *viz.* in the same year 1644; on the last day of the year, and the 67th of his life. So that what has been suggested by some eminent chemists, *viz.* that *Helmont* had changed his sentiments, and had got quite other things in view, e'er he died; appears without any ground; as he lived but a little while after finishing the last, and all that time continued indisposed.

He was very sober, and regular in his way of living; of a firm body, and a healthy constitution. His way of writing is very entertaining: and his style, tho' not always pure *Roman*, yet never fails to be elegant.

We have been assured by persons who knew *Helmont*, and conversed with him, that he was scarce known in his neighbourhood; that he did not apply himself to practice; nor scarce ever stirr'd out of doors: only, a few of his next country neighbours, he used to give his advice to, *gratis*. He had been invited to the emperor's court; as also to that of the Elector *Palatine*, in quality of chymist, and physician to those princes; but he declined both.

*Death.* As he perceived death drawing nigh him, he call'd his son, *Fr. Mercury ab Helmont*; and gave him the following charge: "Take all my writings, "the crude as well as the finish'd ones; and join them together: to your "care I commit them; do with them what you think good. For so it "has pleased almighty God, who directs every thing to the best purposes." This son, with whom the deposit was left, was a person of deep thought, and meditation; but a little tainted with enthusiasm; and in his father's life-time had strolled about with a gang of gypsies. After the father's de-

* De aquis spadanis. † De humoribus. || De febribus. †† De lithiasi.

cease,

ceaſe, he acquitted himſelf of the truſt, by collecting all his pieces together, and publiſhing them juſt as he found them, without any regard to order, conſiſtency, or correctneſs; and beſide, truſted the impreſſion principally to the printer: ſo that we frequently find *Helmont* relating things in one place, which he contradicts in another.

Indeed, 'tis no wonder we don't find the ſame tenor throughout; for, as chemiſtry grew under his hands, and as a world of new views muſt turn up in the courſe of forty years, which he ſpent in gradually improving the art; 'tis eaſy to conceive how there ſhould ariſe a difference between the firſt, and laſt. The firſt, faint attempts of a raw, unexperienced novice; may well be allow'd to differ from the ſolid productions of a veteran, like *Helmont.*

Thoſe he publiſhed himſelf, are all excellent: that *de Lithiaſi*, is incomparable, and goes beyond any of the reſt: that *de Febribus*, is a valuable work. That *de Humoribus* is certainly a fine piece: The *Galeniſts* are here drove out of all their holds; the doctrine of the four elements, four qualities, four degrees, and four humours, with the method of cure by tempering thoſe degrees, are clearly and directly demonſtrated to be falſe, and inſignificant. The book *de Peſte*, which is one of the poſthumous pieces, has a deal of good things; tho' it does not come up to the merit of the former. But the reſt are all ſo much inferior, that one would never ſuſpect them to have come from the ſame hand.

The beſt edition is that of *Amſterdam, in quarto, apud Elzevir.* In the *Venetian* edition *in folio*, there are are a good many pieces, not *Helmont's*. And the ſame may be ſaid of the edition lately publiſhed in *Germany.*

It remains, that we conſider a little, what judgment ſhall be form'd of the man; and, particularly, as to his pretenſions to the univerſal remedy.

*His pretenſions to the univerſal medicine.*

He himſelf proteſts, in the moſt awful manner, in preſence of Almighty God, and as he expects mercy at his hands; that he has a ſingle remedy wherewith he can cure all diſeaſes, without any kind of evacuation, and merely by correction, or alteration. This, we find, not in one place only; but ſomething like it is inculcated in almoſt all his writings. *A phyſician,* he ſays, *who cannot cure the* lepra, *radically, is not worthy the name of a phyſician.——A phyſician, who cannot cure all fevers by one potion of a ſimple diaphoretic, does not deſerve the appellation.——Let every one, who cannot cure all diſeaſes with the alcaheſt of* Paracelſus, *be expel'd the faculty*——And the like.

*Dogma of the archæus.*

But his notion of the origin, and foundation of an univerſal remedy, is very peculiar, and ſavours of that enthuſiaſm which was a part of his character. No poiſon, ſays he, can act on a carcaſs: if, therefore, it have any effect, 'tis by means of life; which life he calls *archæus*; and aſcribes both underſtanding, and knowledge thereto. If now any heterogeneous body happen to be preſent to the *archæus*; it riſes into a fervour, endeavours to expel the hoſtile matter; and, in order to that, exerts all the force of the body. To cure any diſeaſe, therefore, is to pacify, and com-

pofe this *archæus*. This *archæus*, he holds, is irritated at the leaft appearance of any thing heterogeneous: and as its office is to watch over the health, and fafety of the whole body; it is excited at the very fhadow of the enemy, calls its forces to the charge, raifes fevers, and deftroys the whole body. The thing required, therefore, is fuch a remedy as may readily pacify, and lay this unnatural fervour upon all occafions: and this is the univerfal remedy.

This doctrine of *Helmont* would not be fo abfurd, did not he afcribe underftanding to his *archæus*. Setting this afide, the principle which renders poifons deadly, and remedies beneficial, is the circulation of the blood. No doubt but *Helmont* was apprized of this before he died. For *Harvey* had publifhed his difcovery fome years before; which *Helmont* could not but fall into: tho' he might chufe diffembling the matter, in regard it untwifted a good part of his fyftem; which he might want leifure, or inclination to reform, and work a-new.

He adds, that *Adam*, had he retain'd his innocency, would have lived for ever; inafmuch, as he would have fed of the tree of life, growing in *Paradife*: but that, upon his fall, God removed the tree of life, and hid it in the heart of metals. If, therefore, we can any how extract it out of the fame; we fhall ftand the fame chance for immortality as *Adam* did.

Now, whether *Helmont* had any fuch remedy, or tree, as he pretends, is the point to be confider'd: if he had, we muft certainly find fome inftance of the ufe, and effect thereof.

*Vanity of his pretenfions.*

He had three fons; two of which, he owns, he could not cure of the plague, but loft them both: and yet in his book *de Pefte*, he exprefsly declares he could cure the plague, and all other difeafes.

Again, he had a daughter feiz'd at five years of age with a flight leprofy, which afterwards produced livid ulcers, and dry horny fcales over her whole body: he attempted her cure for two whole years fucceffively; but in vain: and yet he is continually boafting, that the alcaheft cures the *lepra* immediately; and he fwears by the immortal Gods, that he is mafter of the alcaheft. However, inftead of applying it, he fent his daughter to the image of the virgin *Mary*, in the hofpital of St. *James*: from whence, he ingenuoufly owns, fhe returned back, perfectly found, in an hour's time.

His wife, too, had been fick for fome time. He did what he could to recover her; but fhe laugh'd at him, as not capable of the cure: nor did all his endeavours avail a ftraw. It happen'd, about the fame time, that *Butler*, the famous *Englifh* phyfician, was clap'd up in prifon for counterfeiting the coin; and *Helmont* was fent for to *Bruffels*, to be an evidence.

Butler's *ftone.*

Here he contracted an acquaintance with *Butler*; and feeing him perform feveral extraordinary cures with his ftone, he ask'd *Butler* how he came by the fecret: *My dear*, anfwers *Butler*, laughing; *unlefs you arrive at the cure of all difeafes by a fingle remedy; you'll be but a novice, tho' you fhould live to the age of* Methufalem.

At

At his return home, *Helmont* told his wife he had now got her remedy; and that ſhe was to be cured by *Butler's* ſtone. Accordingly, the ſtone being ſteep'd in oil of olives, and the oil applied on the part affected, ſhe recover'd to a miracle.

Let us now ſee how he managed his own body, when out of order. If neither his ſons, daughter, nor wife were dear enough to him, to make him apply his remedy; yet ſure he would not have grudged it on himſelf. In page 322 of his works, he writes thus: "On the 27th of *December*, "in the ſixty-third year of my age, I was ſuddenly ſeiz'd with a ſlight "fever, attended with a chilneſs, which ſet my teeth a chattering: "this was ſucceeded by a pungent pain in my ſide, and *ſternum*; a diffi-"culty of breathing; and a ſpitting of blood." We have here a perfect deſcription of a genuine peripneumony, with an inflammation of the ſide, *pleura*, and lungs. *Hippocrates* would here have directed him to forbear letting blood; and to have immediate recourſe to demulcent remedies. Let us now ſee what courſe he really took, and what univerſal remedy was applied on this perillous occaſion.: "I immediately took ſcrapings of "the *penis* of a goat, reduced to powder; and the pain vaniſh'd:" [but the diſeaſe continued.] "The next day, I drank a drachm of goat's blood; "by which, in three days time, the *ſputum ſanguinis* diſappear'd: but "there ſtill remain'd a little cough;" [for he was not yet cured, nor the matter of the diſeaſe carried off.] "This ſtuck faſt by me, accompany'd "with a difficulty of breathing, a continued fever, and intermitting pulſe. "At length, I felt a pain in the ſpleen: to remove which, I took a "draught of wine with *lapis cancror.* and the ſymptoms all diſappear'd:" So far was this mighty chemiſt from applying any chemical *arcanum*, or univerſal medicine; that, we ſee, he took none but the moſt contemptible *Galenical* ones: the genital of a goat, goat's blood, and *lapides cancrorum*: and this in a pleuriſy, peripneumony, and pain of the ſpleen.

*How he order'd his own ſickneſs.*

But let us ſee how he died: He was taken ill of an aſthma, which preſs'd him ſo, that he was obliged to riſe at mid-night, and fetch his breath out at the window. This diſeaſe he could not cure; but let it degenerate into a *vomica pulmonis*. His ſon adds, that he died under a ſlight ſuffocation, and *deliquium*, perfectly ſenſible, and apprehenſive of the approach of death. It were needleſs to ask, what was now become of the tree of life? and why he died at ſixty-ſeven years of age, with the remedy in his power?

*Manner of his death.*

In his treatiſe *de vita longa*, he aſſerts that cedar-wood, reduced into an *ens* by the alcaheſt, is that *primum naturæ*, one or two drops whereof abſterges the matter of all diſeaſe, cleanſes the blood, reſtores the vital juice, and revivifies a man every moment; ſo that with the uſe hereof it were impoſſible for him to die. What abſurdity! And does not *Helmont* rave? The alcaheſt he ſwears he has; and cedar-wood is eaſily procured: What boots it to protract other peoples days to the longeſt period; and to die young one's-ſelf?

His son *Mercury* was master of all his secrets; knew the powers of all his medicines; and all the father did, or could do: and, withal, was a person of great candour, and humanity. This gentleman, being sent for to an excellent lady, the wife of a friend of mine, who had generously entertain'd him in his house a considerable time; with a request, he would cure the lady of a disease in the stomach: he order'd her "every morning, "and evening, to lick upon *Cyprus* vitriol, with the tip of her tongue:" which was all the *arcanum* he knew in such a case.

It appears, then, contrary to the unanimous voice of the whole tribe of chemists, that *Helmont* had not the universal medicine. And if these two persons, the greatest, and most famed for chemical knowledge, that ever lived; and whose pretensions, of all others, stood the fairest; were guilty of direct falshood, and deceit, in pretending thereto: it may be taken for granted, no body was ever yet master thereof.

We have taken all this pains to unravel, and clear up this mighty *mystery of chemistry*; of which so much ill use has been made; and to set the pretensions, and *arcana* of these patriarchs of the chemists on their true footing: that our reader may be prepared to obviate, and cut short the empty boasts of the common chemists, who have profited by the cloud and embarrass wherein the matter has hitherto been involved.

For my own part, after reading the writings of the two authors abovemention'd; I was at once discouraged, and cast off from all thought of ever practising physic more. For, as they assert it needless to enquire into the cause, nature, seat, symptoms, effect, *&c.* of a disease; or to trouble one's-self with regimen, diet, *&c.* since with one little, simple medicine, all diseases may be cured, alike; and death shut out from every door: I was hence struck with the utmost inquietude; and began to spend my days, and nights, in a sollicitous perusal of their doctrines, and experiments, to get some opening into the secret; as never suspecting, that men, christians, scholars, artists; nay, and men of the largest minds, the finest parts, and the most extensive knowledge, and skill, the *Genii* of their age, the founders of useful arts, and the benefactors of mankind, should be guilty of such mean, premeditated falshood, back'd with all the religion of oaths, and imprecations.——But I was soon disabused: by an inquiry of some who had been personally acquainted with *Helmont*, and even of his son; I learn'd how much a warm imagination, a working, brooding head, and a spice of the spirit of enthusiasm, may do; and that he was not less ridden, and abused by his own distemper'd reveries, than his readers are by his mighty assertions.

From *Paracelsus*'s, and *Helmont*'s time, the number of chemists, and writers in the art, grew immensely; so that, to rehearse them all, would be endless. The art once form'd, and laid out, there was matter for infinite heads, and hands, to dispose, digest, build, pull down, teach, controvert, pursue, fill up, reduce, and apply it. Accordingly, there is scarce one art to be named, of so late a standing, that can reckon up so many authors; witness *Borelli*'s *Bibliotheca Chemica*, printed at *Heidelberg* in 1653; wherein

*Infinity of authors in chemistry.*

wherein no leſs than four thouſand writers, already extant, are enumerated; and yet he mentions none but thoſe of his own knowledge. Others, who took more ſcope, found above double that number at the ſame time. It may be added, that the ſeventy years elapſed ſince, have produced more than all the ages before.

Here, therefore, we muſt end our career; the field is too vaſt to enter on. We have conducted chemiſtry from its riſe to its ſtate: its progreſs is now at an end; and the rivulet we have hitherto purſued through all its tours, and augmentations, now terminates in an immenſe ocean; where, if we cannot conduct you to all the coaſts, and iſlands; we can, however, point out the principal roads, and ports; mark the rocks, and dangers; and inſtruct the young adventurer how he may purſue his voyage with the moſt ſecurity, and advantage. For chemiſtry is not only a dark, and intricate, but a dangerous road; and he who enters on it, muſt proceed, not only with addreſs, but with circumſpection, and care. That part which relates to metals, is remarkably perilous: The ſingle vapour of arſenic may either immediately ſuffocate, or occaſion a debility for ever after; And an author who relates an experiment, without expreſſing every circumſtance thereof in terms at length, is not only uſeleſs, but even dangerous: 'Tis on theſe minute circumſtances that the event of every operation depends; and an alteration in any of theſe, may not only prevent the ſucceſs of the whole, but even render it, unexpectedly, fatal and deadly. For an inſtance: if in preparing *ſp. nit. dul.* an author ſhould only ſay in the general, *Pour the ſpirit of wine on the nitre, in a tall glaſs*, the operator would certainly be ſuffocated. To avoid this, it ſhould be ſaid, *Inſtil the ſpirit, drop by drop, under the chimney.* 'Tis not ſafe trying any thing, therefore, after an author, unleſs he be of aſſured accuracy, and note even all the collateral circumſtances, to be guides to us.

*The operations of chemiſtry attended with great danger.*

*Choice therefore to be made of the authors we follow.*

To impreſs this the ſtronger; I ſhall ſubjoin an inſtance of the peril myſelf underwent: I had long entertain'd an opinion, that phoſphorus might be procured from human blood: to put the matter to a proof; I took a quantity of blood, and extracted from it every thing that fire would bring away: the remainder was a thick, viſcid matter: this matter I burnt with fire in a cloſe, fortified retort, and came at midnight with a candle, to ſee the effect. I preſently perceiv'd the neck of the retort was beginning to be ſtuff'd with a thick matter, which aſcended from bottom to top; and foreſaw the neck would ſoon be quite cloſed; and apprehended the conſequence. Accordingly, I immediately withdrew; and was no ſooner gone, than the aſcending oil, by its elaſtic force, burſt the veſſel into a million of pieces; and in one moment ſet the whole room, as it were, in a flame. Had I been by, I had doubtleſs periſh'd; either by the fragments of the glaſs, or the fumes of the oil; or elſe my reſpiration had been inſtantly ſtop'd by the fire.

We proceed, therefore, to chuſe out the beſt authors; and thoſe we would recommend for a regular ſtudy of chemiſtry. Theſe we ſhall reduce into four claſſes.

*Theſe authors reduced to Claſſes.*

The

*Syſtematical authors.* The firſt claſs includes the *ſyſtematical* writers, or thoſe who have collected all the known things, *i. e.* all the operations in chemiſtry into a body, and digeſted them in form and order of an art or inſtitution, for others to learn by; commonly with ſome addition of their own reaſonings at the end of each operation. Of theſe,

Beguinus. JOHANNES BEGUINUS *claims the firſt place, for his* * TYROCINIUM CHYMICUM. The book is in 12°, and has been often reprinted, with notes by ſeveral hands.

Crollius. OSWALDUS CROLLIUS comes next, on account of his † *Baſilica Chymia.* He was a phyſician of great learning, the emperor's chemiſt; and a ſtrenuous adherent of *Paracelſus,* whoſe pupil he had been. *Hartman* has wrote a comment on him, under the title of *Hartmanni commentatio in Baſilicam chymiam,* wherein are abundance of cautionary rules, and the operations every where exactly deſcribed. The work is in 8*vo*; it is alſo found among *Hartman*'s works in *folio.*

Glaſer. GLASER, a chemiſt in the court of the *French* king, ſucceeds. He wrote a *French* treatiſe in 12°, entitled *Traitte de la Chymie,* wherein the circumſtances of the proceſſes or operations, are briefly and faithfully deſcribed.

NIC. LE FEBURE, or FEVRE, by nation a *Dutchman,* flouriſh'd in the courts of *England* and *France,* as chemiſt to king *Charles* II. and *Louis* XIV. He publiſh'd a book in *French* under the title of *Traitte de la Chymie,* in two volumes in 8*vo*; afterwards in 12°, which latter is to be prefer'd. He is highly to be valued and commended, as both delivering the whole art, with all the proceſſes; and as he every where preciſely notes all the minuteſt circumſtances. No body is more faithful and accurate in the accounts of his experiments; he is particularly careful to note all the dangerous and deadly proceſſes: But he has this defect, that in his reaſonings he has too much of the chemical ſpirit; and talks too largely of the virtues of his medicines.

Mr. *Boyle* quotes him under the characters L. F. and mentions his *Ens primum* of balm, whereby he pretended to reſtore youth and vigour to old worn-out animals.

Lemery. LEMERY the elder, a celebrated member of the royal academy of ſciences, and chemiſt of the late king *Louis* XIV. has given us an excellent work in *French,* entitled *Cours de Chymie.* The beſt edition is that of *Paris* in 8*vo* 1713, which has many things not in any of the precedent ones. It contains all the principal operations belonging to the three kingdoms; all which are deſcribed with great candour, and no leſs accuracy. To each are added ſcholia or notes, containing the phyſical reaſons thereof. He is every where minute in enumerating all the circumſtances of the proceſſes, and particularly where any danger might ariſe ||.

Jo.

* Novitiate or Apprenticeſhip of chemiſtry.

† Royal Chemiſtry.

|| Monſ. *Lemery,* who makes ſo great a figure among the modern chemiſts, was born at *Rouen,* in 1645. His firſt notion of chemiſtry he got from an apothecary of the place, to whoſe diſcipline he was committed; but ſoon perceiving it muſt be another-

JO. CONR. BARCHAUSEN, profeſſor of chemiſtry at *Utrecht*, deſerves well to be read. He is an honeſt writer, and ſufficiently accurate; he delivers good matter in an excellent ſtyle, tho' his reaſonings are not ſo much to our mind. His *Elementa Chemiæ* are printed in 4*to*, and contain a great many particular experiments, and manual operations, no where elſe to be met withal. Barchauſen.

LE

another-guiſe ſcience than what his maſter knew, he went to *Paris* in queſt thereof. Here he applied himſelf to Monſ. *Glaſer*, demonſtrator of chemiſtry in the king's garden; but finding his ſecond maſter full of obſcure notions, and yet a niggard of ſuch notions as he had, he reſolved on a tour thro' the kingdom, to learn what he could get from the chemiſts abroad. At *Montpellier* he made a ſtay of three years; and being now pretty well furniſh'd, he could give lectures; and undertook to practiſe phyſic. In 1672, after a peregrination of ſix years, he return'd to *Paris* an accompliſh'd chemiſt; and exhibited his firſt courſe of chemiſtry in the laboratory of his friend M. *Martin*, apothecary to the prince of *Conde*. Animated with the ſucceſs hereof, he enter'd himſelf in the company of apothecaries; and open'd a laboratory of his own in the *Rue Galande*, where he perform'd courſes with infinite applauſe, all the virtuoſo's of *Paris* reſorting to his cave. Foreigners ſoon flock'd in a-pace from all parts; and *Paris* was then the ſeat of chemiſtry, whither the ſtudents repair'd, as *Leyden* is now.

His preparations were already come into great vogue; and ſome of his noſtrums, particularly the magiſtery of *Biſmuth*, brought him money in abundance.

The face of chemiſtry had till then been ſtrangely clouded: Quaint, enigmatical terms, and imaginary ſympathetic properties of bodies every where disfigured it; or, as he himſelf expreſſes it, a little truth was ſo diſſolved in a great deal of falſehood, that it was become inviſible, and the two almoſt inſeparable. M. *Lemery* firſt began to diſſipate the affected obſcurities of chemiſtry; he reduced it to more ſimple, preciſe and determinate ideas; threw out a deal of the jargon, and accommodated it to the taſte and philoſophy of the time.

In 1675 he printed his *courſe of chemiſtry*, which was receiv'd with great applauſe. Editions ſucceeded editions at an unuſal rate; and it was not long e'er it made its appearance in the *Latin*, *Engliſh*, *Spaniſh*, and *High-Dutch* languages. Some of his ſecrets, however, he ſtill reſerved in petto; particularly a very mild emetic ſurer than ordinary; and a meſenteric opium, wherewith he is ſaid to have perform'd notable cures: he is even ſaid to have contented himſelf with making ſeveral of the operations more eaſy than they had been; without revealing the utmoſt degree of facility, which he was acquainted with.

In the year 1681, the religious troubles coming on, M. *Lemery*, who profeſs'd the reformed religion, began to ſhare therein; being order'd to lay down his courſes in a limited time. The elector of *Brandenbourg* hereupon made him an invitation, by his embaſſador M. *Spanheim*, to come to *Berlin*, where he would erect a poſt of *Chemiſt*, on purpoſe for him; but he declined it; and in hopes of ſome connivance, perform'd courſes after the time prefix'd: but the court growing more ſevere, he came over into *England* in 1683, and was favourably received by King *Charles* II. who gave him ſome hopes of a proviſion: But finding the effects were like to follow very ſlowly, if at all, he return'd to *France*, and took the degree of doctor in phyſic at *Caen*; hoping to be ſhelter'd under that quality: but the edict of *Nants* in 1685, prohibiting the practice of phyſic to thoſe of the religion, he was entirely ſtript of all employment, and left without reſource.

The good man, not able to ſupport himſelf under his ſufferings, determined to put an end to 'em at once; and, accordingly, embraced the roman catholick faith. Upon this, practice, courſes, the ſale of his preparations and peaceful days return'd in abundance. Henceforward he began to apply himſelf to pharmacy; and in 1697 publiſh'd two large volumes, entitled, one of them, *Pharmacopée univerſelle*, the other *Traité univerſel des drogues ſimples*.

Upon

*Le Mort.* LE MORT, profeſſor of chemiſtry in the univerſity of *Leyden*, is the laſt we ſhall mention. He goes thro' and explains every thing; but inſiſts on abundance of operations, which have long ſince been diſuſed: his work is printed in 4*to*.

*Metallurgic authors.* The ſecond *claſs* contains the *metallurgic* writers: by *metallurgia* is underſtood the whole art of preparing and working metals, from the glebe or ore, to the utenſil. This part of chemiſtry, therefore, is employ'd in the finding, digging, purifying, and rendering of metals malleable; and conſiſts of four parts: The 1ſt teaches how metals grow in the mine, how they are diſcover'd, and how procured out of the ſame; the 2d how to ſeparate the metallic from the other matter of the ore; the 3d how to reduce the ſeparated metal to its ſimplicity, and ductility; and the 4th to work, gild, poliſh, and imitate the finer metals in the coarſer. Among the authors to be read herein,

*Agricola.* JOH. AGRICOLA deſerves the firſt place, the author of a treatiſe *de Re Metallica*, reprinted a great number of times in *folio*. This work is a proof of the author's extraordinary learning and experience: by viſiting all the mines, and converſing freely with the miners in *Germany*, he got a thorough knowledge of the whole proceſs of metals; and from him moſt of the following writers have taken the greateſt part of what they know. He wrote with the exacteſt fidelity, and in an elegant *Roman* ſtyle; ſo that we conſult him as we would an oracle, upon all occaſions.

In the firſt part of the *metallurgia*, or the diſcovery of metals, he is the only author; he deſcribes with great accuracy and minuteneſs, all the arts and inſtruments made uſe of to diſcover mines, and to know whether in any given glebe, there be metal, and of what kind. Nor is he defective in any of the other parts. Several authors have wrote comments on him; but he is clear enough without any—The beſt edition is that of *Francfurt*, containing a treatiſe *de Re Fodinaria*, after that *of Metals*.

*Ercher.* LAZARUS ERCHERUS, or AB ERCKEREN, deſerves the ſecond place. He was ſuperintendent of all the mines in *Germany*, *Hungary*, *Tranſylvania*, *Tyrol*, *&c.* to three emperors; whence he was furniſh'd with a compleat ſtock of metalline knowledge.

He ſhews by what ſigns to know where metals are; then, how the veins are to be open'd; how dug; how ſeparated; purified by mercury, cementation, *&c.* He is really an experienc'd candid, and honeſt writer; he relates nothing but what he had himſelf ſeen, without a word of theory or reaſoning; and every where ſpeaks as if he were actually ſitting before the furnace, and relating what paſs'd.

Upon revival of the royal academy in 1699, he was elected *aſſociate chemiſt*, and e'er the end of the ſame year, upon the death of M. *Bourdelin*, *penſionary chemiſt*. He then enter'd on a great work, which he read to the academy *piece-meal*; and at length publiſh'd together; *viz.* the *Traité d'antimoine*, wherein that important mineral is turn'd and tortured by diſſolutions, ſublimations, diſtillations, calcinations, *&c.* a thouſand ways, and into a thouſand forms, with regard both to medicine and philoſophy. From this time he began to droop under old age; ſurrendered his place of penſionary in favour of his ſon, and died of an apoplexy, in 1715.

His

His way is thus: In *Hungary* there is ſuch a mountain; wherein you have ſuch an Earth; beat or grind it into powder, and waſh it in water, and it will be of ſuch a colour, ſmell and weight; and will contain ſo much gold, ſo much ſilver, ſo much copper. In ſuch manner he teaches how it is to be expoſed to the fire, and how burnt; what rules and ſigns are to be obſerved therein; how the fire is to be rais'd or diminiſh'd, *&c.*

He never fails enumerating every circumſtance; and always in the moſt open artleſs manner; and in a clear, obvious ſtyle; adding figures, for further illuſtration: His book was wrote in *High-dutch*; and printed in *folio*: and of ſuch value is it held among the curious, that Mr. *Boyle* laments his not underſtanding that language, merely for the ſake of reading this author. But it has ſince been tranſlated into *Latin*, with excellent notes; ſo that this ſingle work might almoſt ſuffice for the whole art of metals.

The number of writers in the *metallurgia*, is almoſt infinite; the greateſt part of *Borelli*'s 3000, are of this Claſs: But the practical writers moſt of 'em take their matter from thoſe two above mention'd; and the reſt have little more than ſpeculation, and theory. However, it may be proper to diſtinguiſh.

Jo. RUDOLPH. GLAUBER, a celebrated chemiſt of *Amſterdam*, accounted the *Paracelſus* of his time. He had travel'd much, and by that means attain'd to a great many ſecrets. He wrote above 30 Tracts; in ſome of which he acted the phyſician, in others the adept, and in others the metalliſt. He principally excell'd in the laſt capacity; and yet, even here, he comes ſhort of *Agricola* and *Ercher*, in point of fidelity, ſimplicity, and exactneſs; being ever forward to mix his own ſpeculations, and reaſonings along with the matters of fact. Glauber.

He was a perſon of eaſy, genteel addreſs; and beyond diſpute well verſed in chemiſtry; being author of the ſalt ſtill extant in the ſhops under the title of *Sal Glauberi*; as alſo of all the ſalts by oil of vitriol, *&c.*

He is noted for vaunting and extolling his arcana and preparations; and is even ſaid to have traded a little unfairly with his ſecrets: The beſt of 'em he wou'd ſell at exceſſive rates to chemiſts, and others; and would afterwards ſell 'em over again; or make 'em public, to increaſe his fame: Whence he was continually at enmity with one or other.

The principal of his writings are *de Furnis*, and *de Metallis*; which tho' wrote in *Dutch*, have been tranſlated into *Latin*.

It was this *Glauber*, who ſhew'd before the States of *Holland*, that there is gold contain'd in ſand; and made an experiment thereof to their ſatisfaction: But what *Pliny* ſaid of *C. Caligula*, *ars detrimento erat*, obtain'd here likewiſe; ſo much lead, fire, and labour being employ'd in procuring it; that the art would not bear its own charges *. However, he ſhew'd pretty *His experiment before the States of* Holland.

* *Sthall*, however, thinks, it might ſtill turn to account; the proceſs is very ſimple, and takes up little time. All they uſe in it is ſilver, ſand, and litharge; and the ſilver does not waſte in the operation, but is refined thereby.

 plainly,

plainly, that there is no earth, ſand, ſalt, ſulphur, or other matter; but has its ſhare of gold.

*Geber* the *Arab* above-mentioned, has many excellent things relating to the art of metals; but he is too full of the philoſopher's-ſtone, and conſiders metals too much with a view to their exaltation.

*Paracelſus* has ſomething on the ſame ſubject; but written in ſuch a manner, that it is not eaſy to be underſtood.

*Writers in alchemy. Several branches of alchemy.*

The third claſs contains the *Alchemiſts*, or thoſe who teach the art of converting baſer metals, into more noble. Alchemy may be divided into three branches: The firſt ſhews how to *ſeparate* the glebes, or corpuſcles of gold contain'd in other metals: The ſecond how to *digeſt* and *ripen* the crude, imperfect matter of gold in other metals: The third, to *tranſmute* or convert one metal into another. The firſt part belongs to the *metallurgia:* The laſt is employ'd in ſearch of the *philoſopher's-ſtone*, *i. e.* a powder, a little whereof caſt into a quantity of any metal in fuſion, converts it all into pure gold. Not contented with this, the alchemiſts will needs carry this laſt part much farther: *viz.* To the finding of the *philoſopher's ferment*, a matter which being pour'd on gold, converts it into the philoſopher's-ſtone.

The road to fame by the way of alchemy, is very ſlippery and hazardous. The candidates hereof, inſtead of the immenſe riches the art promiſes, are frequently rewarded with the extremeſt indigence; and plentiful fortunes often have been ſquander'd away in the purſuit. This, however, we venture to ſay, that no man, who has a tolerable knowledge of alchemy, can ſpend much money therein. The principal occaſion of expence, ariſes hence, that thoſe who pretend to teach the art to others, or to attain, and practiſe it for 'em; fraudulently require a deal of gold and ſilver, as neceſſary in the operation *: But the truth is, an experiment is as well made with

* *Kircher* gives a long detail of the ſlights, and devices practiſed by the alchemiſts to impoſe on the ignorant: In all their operations they uſe gold, either to gild the metals they work on, or to make appear as if ſome part were converted. If the eye be off 'em, they will throw gold into the crucible: And if you watch 'em cloſe, they have hollow ſpatula's at hand, wherein they have put gold; ſo that when the matter which cloſed the ſpatula is melted, the gold drops in: They will put gold in the coals, in the bellows, or at the bottom of the crucible; covering it over with a thin lay of earth, or the like: They diſguiſe gold by divers preparations, and preſent it under ſuch foreign forms for a ſecret that augments gold, and tranſmutes metals: They can reduce ſilver into leſs bulk; and render it indiſſoluble in aqua fortis, by ſaturating it with oil of vitriol; in this diſguiſe they play various pranks with it: They tinge veſſels of gold, and ſilver, with the colours of iron or copper; and by mercury reſtore them again: They fix mercury, and tinge it divers ways; make nails half gold, half iron, and give the gold part the colour of iron, to have the reputation of converting it. Such a train of deceits was, probably, what put the Lawyers upon enquiry whether alchemy might not be prohibited by law; accordingly, there is a conſtitution of pope *John* XXII. ſtill extant, whereby the alchemiſts are decreed infamous, condemn'd to impriſonment, *&c.* The faculty of *Paris*, not leſs ſevere than the pope, condemn'd *Palmarius* for writing on the philoſopher's-ſtone; and by an arret dated the 28th of *January* 1609, injoyn'd him to abjure his error and

with a single grain of gold, as with a tonn; and whatever gold is used on such occasion, still remains gold; and may be recover'd without diminution. A man that loses a single grain of gold, does not deserve the name of an alchemist.

As to the authors on this head; 'tis hard to say that one is better than another: Since it does not appear that any of them were possess'd of the secret*. We shall therefore content ourselves to propose such, as by the consent of all ages, have been allow'd the best. These are,

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and live and die in the doctrine of *Hippocrates*; sequestring all his preferments to the use of the *Hotel Dieu*.

But it must not be omitted that this zeal against alchemy, in some, was founded on another principle, *viz.* that it is impious to change any of the works of the creator.

* Whether ever there were such a thing as the philosopher's-stone, or any actual transmutation, is a point of the utmost delicacy. To prepare a man to conclude of it, a thorow knowledge of the case, and a great deal of pains and attention to it are required; but such preparation, necessary to render the conclusion safe, makes it almost impracticable to conclude at all. The common ways of judging, *viz.* by analogy, or from one fact, to another similar one, will not do. Many of the alchemists have been visionaries; and many of them deceivers: innumerable attempts have been vain; all this is granted: But a man that without more ado can infer the same of all the rest, is not to be trusted to make conclusions. *Morovius* in a letter to *Langelot*, relates several facts, which appear as well supported as the most authentic histories we have; But a chemist would be laugh'd at, that should plead these in behalf of the idle pretences of many of the rest.

The reasonableness and possibility of the thing, we shall hereafter have occasion to consider: Testimony is what we have now to do withal. *Helvetius*, physician to the prince of *Orange*, in his treatise, entitled *Vitulus Aureus*, affirms, that a chemist came to him, and told him that he had read some of his treatises, wherein he seem'd to question the reality of any transmutation; and that he came to shew him how well his doubts were founded. Bidding him, therefore, take a piece of a leaden spout fasten'd to the wall of the room, and melt it; the chemist threw in a little yellow powder: Then pouring the whole upon the ground, the lead was all gold. Some time afterward he gave *Helvetius* a piece of matter about the bigness of a turnip-seed, and promis'd to see him again the next morning: But *Helvetius* wanting patience to wait his coming, cast the matter into six drachms of melted lead, which became converted into gold.

*Kunkel* a very sensible, discreet, and learned person, made no doubt of the existence of the philosopher's-stone; nay, he gives us proof of it, of his own knowledge: The elector of *Saxony*, he assures us, had such a tincture; and his son *Christian* I. had the same for five years after his Father's death.

I am surprized, says the excellent *Casp. Bartholin*, that people should still be in doubt whether metals may be changed into gold: I myself was witness of such a transmutation.

That curious and industrious chemist *Becher* observes, that there are so many proofs of transmutations, a man must be stupid to stand out against them. The emperor *Ferdinand* III. says he, did himself change three pounds of mercury into two pounds and a half of pure gold; and this by means of a single grain of tincture. This notable transmutation was perform'd at *Prague*; and a medal was struck of the same gold, in memory thereof. The legend on the front is, A DIVINE METAMORPHOSIS, PERFORMED AT PRAGUE, THE XVth OF JANUARY M.DC.XXXVIII, IN PRESENCE OF THE EMPEROR FERDINAND III.

We forbear to enumerate more instances, which Mr. *Boyle*, *Borrichius*, *Delrio*, &c. would furnish. We shall only add,



that

Roger Bacon.
Ripley.
Lully.
John and Isaac Hollandus.
Geber.
Basil Valentine.
Paracelsus.

*Common principle of the alchemists.* The common principle on which these authors proceed, is, that all metals consist of mercury and sulphur, so united together, as that the mercury is hereby render'd fix'd, and stable. The whole metalline nature, they hold to reside in, and depend of these two; so that the philosopher's-stone is to be sought in metals; alone tho' the two *Hollandus's*, as already observed, teach, that it may not only be made from metals, but from blood, urine, or any other thing in nature.

*Van Zuchten.* Alex. Van Zuchten or Sugten, a noble *German*, and a disciple of *Paracelsus*; having likewise the reputation of a conjurer: he wrote two little treatises, wherein are contain'd many of the finest, and choicest secrets of the art: The one *de Chymia*, the other *de Antimonio*. In the latter he asserts, that the philosopher's-stone may be prepared of mercury, and antimony; after purifying the antimony of all its sulphur.

In a subsequent treatise, which he calls an illustration of the former, he

that M. *Homberg* himself has actually converted silver into gold by heat alone. *Memoirs de l'Academie. An.* 1709.

It must not be omitted, that the processes described by the alchemists, not succeeding with us, is not a sufficient objection to 'em. There are infinite ways in which an experiment may fail: Air, fire, water, &c. will be shewn to have a great effect, on the operations of chemistry; and yet are all exceedingly changeable; so that the same experiment scarce ever succeeds twice exactly alike. Mr. *Boyle* is very large on the failure of experiments from differences in fire. *Van Helmont's* processes have a great many of 'em been exploded as false by later chemists, and yet have succeeded with Mr. *Boyle*. A single circumstance in a thousand is enough to untwist an operation: and as the alchemists may have been sufferers by such accidental alterations; so, no doubt, they have been gainers too. Some of their transmutations were apparently owing to some fortuitously favourable disposition in one or other of the elements, and for want of a like disposition cou'd never be repeated. Such was the case of a friend of Mr. *Boyle*, who laying some gold to digest in a sort of aqua fortis, procured a tincture therefrom, which converted silver into gold. But after that aqua fortis was gone, he could never make more.

Hear the candid and experienc'd Mr. *Boyle* himself: he observes that such accidents often befall artists irreparably: *Glauber* tells us of several ways, by which he made gold once, but could not do it again: The prince of *Mirandola* in his treatise *de Auro* tells us of several persons whom he knew had the like success in preparing both gold and silver; And I could instance in my own acquaintance those who have once or twice made *luna fixa* (which abides the trial of aqua fortis, and only wants the tincture of gold) or some other gainful experiments, and have since in vain attempted the like, yet cannot be prevailed on to desist from their uncertain hopes. The most experienc'd mineralist I ever met with, has assured me he should quickly grow rich, could he but constantly perform what he has several times perform'd. Many experiments succeed in small quantities of matter, which fail in greater: Several projectors, and particularly chemists, have dearly bought the knowledge of this truth. *Useful. of Experiment. Phil.*

car-

carries on the process of mercury and antimony, till gold arises therefrom; but not pure gold: for, after having stood all the other tests, or essays; upon amalgamating it with mercury, and laying it to digest, the whole was render'd volatile, and went off in fumes.

NIC. CENTIVOGLIO, or rather SERENUS, denominated SCOTUS, deserves a place in this class. *Centivoglio* was a servant, or rather companion of this *Serenus*; who, tho' a gentleman of a good family in *Scotland*, lived a rambling life in *Hungary*, *Poland*, and other countries; performing many surprizing experiments wherever he came. When near the point of death, he call'd his friend *Centivoglio*, and intreated two things of him; to take care of the publication of his MSS; and to marry his widow. *Centivoglio* perform'd both; but in the edition of his works, suppress'd *Serenus*'s name, and clap'd his own in its place. Centivoglio.

The titles of his pieces are *Novum Lumen Chemicum*, and *Dialogus de Mercurio & Alchemista*. In these he maintains with great strength of reason and experiment, that sulphur and mercury united, are the constituents of every metal: By sulphur he means, with *Geber*, the sun's rays.

In the last century, there appear'd two considerable writings in the same kind; the one under the name of *Agricola*, the other under that of *Philalethes*: Both said to be *Englishmen*, and supposed to be originals. But upon perusing 'em they seem'd to us chiefly taken from *Van Zuchten*. Another styles himself *Pantaleo*, to whom we are indebted for two pieces, entitled *Bifolium Hermeticum*, and *Tomba Semiramidis*. He seems to have been a *German*. But the scarcest author is *Artephius*; who if he be near so antient as is given out, *Paracelsus* and *Van Zuchten* must have taken abundance from him. Agricola *and* Philalethes. Pantaleo. Artephius.

Several other authors have since wrote of the subject; the greatest part whereof, together with those already mentioned, are found in two collections printed in *Germany*; the one under the title of *Turba Philosophorum*, in 5 vol. The other under that of *Theatrum Chemicum*, in 4 vol. in 4to, which may serve as a chemical library *.

The

* Dr. *Dee*, and Sir *Ed. Kelley*, must not be here forgotten; who being profess'd associates, their story is best deliver'd together. They have some title to the philosopher's-stone in common fame, which in this point goes a great way; *Dee*, beside his being deep in chemistry, was well versed in mathematics, particularly geometry, and astrology: but *Kelley* appears to have been the leading man in alchemy. In some of *Dee*'s books are found short memoirs of the events of his operations, as *Donum Dei* 5 ounces; and in another place, *This day* Kelley *discover'd the grand secret to me, sit nomen Domini benedictum.*

*Asmole* says absolutely, they were masters of the powder of projection, and with a piece no bigger than the smallest grain of sand, turn'd an ounce and a quarter of mercury into a full ounce of pure gold; but here is an equivoque: for granting 'em possess'd of the powder, it does not appear they had the secret of making it. The story is, that they had found a considerable quantity of it in the ruins of *Glastenbury-abbey*, with which they perform'd many notable transmutations, for the satisfaction of several persons. *Kelley*, in particular, is said to have given away rings of gold-wire to the value

*Writers who apply chemistry to philosophy, medicine, &c.*

The fourth class consists of such as have applied chemistry to the uses of natural philosophy, medicine, and other arts. The princes in this way, are,

J. B. VAN HELMONT, from whom the rest have borrowed abundance of experiments.

Boyle.

*The honourable* ROBERT BOYLE Esq; that prodigy of knowledge, and application, excels not less as a chemist, than as a natural philosopher. His character is one of the most amiable, and desirable in the world: No body ever made more experiments, or with more care and caution, than he; nor does any body relate the events thereof with more candour, and fidelity. He is ever exceedingly wary and reserved in drawing conclusions from his experiments; and rarely concludes too much. He held a very amicable correspondence with all the chemists, and other *Virtuosi* of his age; and thus effected a kind of commerce, or communication of secrets. Add, that he was always perfectly frank in imparting what he had learnt, or discover'd, to the public.

*His works.*

He gives abundance of good things relating to *fossils*, their origin, separation, preparation, purification, and the ways of fitting them for human uses: as also to *vegetables*: but he is chiefly admired as to what relates to *animals*, and the analysis of their parts; in which he follow'd the path trod by *Helmont*, in his book *de Lithiasi*. A noble instance hereof we have in his history of *human blood*; which contains abundance of the most valuable, and exquisite

lue of four thousand pounds, at the marriage of his servant-maid, which were made after this manner: And a piece of a brass warming-pan being cut out by order of queen *Elizabeth*, and sent to 'em; when abroad, was return'd pure gold. Add, that *Dee* made a present to the landgrave of *Hesse* of twelve *Hungarian* horses; which could never be expected from a man in his circumstances, without some extraordinary means.

In 1591 they went into *Germany*, and settled some time at *Trebona*, in *Bohemia*; the design of which journey is somewhat mysterious. Some say their errand was to visit the alchemists of those countries, in order to get some light into the art of making the powder. Accordingly, they travel'd about those parts, thro' *Poland*, *&c.* in quest thereof: and some say attain'd it; some not. Others will have them sent by the queen, as spies; and that alchemy was only a pretence, or means to bring them into confidence with the people. So, a book which *Dee* afterwards publish'd, *Of Spirits*, is conjectured to be, like *Trithemius*'s, mere cryptography; which is the light Dr. *Hook* takes it in.

They were no sooner gone, than *Dee*'s library was open'd, by the queen's order, and four thousand books, and seven hundred manuscripts taken away, on pretence of his being a conjurer. That princess soon after used means to bring him back again; which, a quarrel with *Kelley* happening to promote, he return'd in 1596; and in 1598 was made warden of *Manchester* college, where he died.

For *Kelley*, the emperor suspecting he had the secret, clap'd him up in prison, in hopes to become sharer with him; but set him at liberty again, and again imprison'd him: from whence endeavouring to make his escape, by the sheets of his bed ty'd together; they happen'd to slip, and let him fall; by which he broke his leg, and soon after lost his life.

things;

things; and on every occaſion he endeavours to found his reaſonings on experiments. His treatiſes of the *unforeſeen failure of experiments*, and *ſceptical chemiſt*, ſhew his great modeſty, and moderation; and how far he was from that common vice of the chemiſts, boaſting, and promiſing more than he could perform.

He is author of a vaſt number of pieces, all compoſed in the ſame ſpirit. They are ſo many, and printed ſo ſeparately, that it is exceedingly difficult to procure a compleat Collection. His ſtyle is a little looſe, and diffuſive; and the courſe of his writings ſometimes interrupted with digreſſions, and particularities not very eſſential *. *Writings.*

One objection is made to him in his chemical character, *viz.* that taking the virtues of his preparations on the report of other people, he commends ſome of them too much, and attributes virtues to them which experience does not avow. For, as he did not practiſe phyſic himſelf, his way was, upon making any new preparation, to give it ſome phyſicians to make trial thereof; and they, it ſeems, out of complaiſance, would ſpeak more largely of it than it deſerved. Hence, thoſe profuſe commendations he beſtows on the ſpirit of human blood and hart's-horn in phthiſical, and on the *Ens Veneris* in rachitical caſes. *Overſight.*

As to the point of credulity commonly charged on Mr. *Boyle*; there does not ſeem to be any great foundation for it: Nobody inquires into things more ſeverely, or ſpeaks of them more dubiouſly than he. True, a long, and intimate acquaintance with the writings of *Paracelſus*, and *Helmont*, might poſſibly have ſome effect on the bent of his mind; and induce him to give too much belief to many of the *arcana* they pretend to: and the more ſo, conſidering the great number of ſtrange incidents, and events which had fallen within his own obſervation. *Credulity unjuſtly charged on him.*

Jo. BOHNIUS, profeſſor at *Leipſic*, deſerves to be read again, and again. His *Diſſertat. Chemico-Phyſ.* publiſhed in 8°, beſide an uncommon reading, ſhew that he has made a good number of experiments. And as to his reaſonings, nobody goes beyond him. His treatiſe *de Acido & Alkali*, is excellent; and has let a deal of light into the Affair. *Bohnius.*

HOMBERG is one of the moſt expert, and maſterly chemiſts of our age. He has diſtinguiſhed himſelf by a great number of general experiments, as well as by his reaſonings; which are always perfectly fine, and clear, and conducted with all the ſeverity of mathematics. Natural hiſtory had received a deal of light at his hands, had his life been continued. He was a perſon of great genius, profound skill, and indefatigable induſtry: he was ſupported by the duke of *Orleans*, late regent of *France*; and perform'd experiments at his expence; which gave him an opportunity of trying many things out of the reach of a private perſon. *Homberg.*

* In the late abridgment of his works, in three volumes *in quarto*, 'tis to be hoped all theſe inconveniencies are removed.

His writings are difperfed in the memoirs of the royal academy of fciences, publifhed firft by *Du Hamel*, then by *M. Fontanelle*; and in the laft edition of M. *Lemery* *.

OTTO TACHENIUS is a good, and experienced author; but too deeply poffefs'd of the notion of alcali, and acid: to which he reduced, and wrefted every thing.

The

* Monf. *Homberg*, the great glory of the royal academy of fciences, was born in the *Eaft-Indies*, at *Batavia*, in the ifland of *Java*, in the year 1652: his father was a *Saxon* gentleman, who having from his youth been ftripp'd of his eftate by the conquefts of the *Swedes* in *Germany*, went to feek his fortune in *Afia* in the fervice of the *Dutch Eaft-India* company; where he obtain'd the Command of the arfenal of *Batavia*. Our chemift was his fecond fon, by the widow of a *Dutch* officer, whom he married on the place. The youth was early deftin'd for ftudy; but the exceffive heats of the climate afforded but little room for application thereto: till upon his father's quitting the fervice, and the *Indies* at once; and removing with his family to *Amfterdam*.

M. *Homberg*, now at liberty to follow his natural propenfity, was fent to *Jena*, and *Leipfic*, to ftudy law; and in 1674 was admitted advocate at *Magdebourg*. But he foon perceiv'd there was fomething elfe in the world to be known, befide the arbitrary laws, and conftitutions of men; and the fpectacle of nature began to draw his attention, and intereft his curiofity. His eyes were firft turn'd upon plants: in the day-time he would fteal to the mountains, to learn the names, kinds, &c. thereof; and in the night obferv'd the ftars, and learn'd the names, and difpofitions of the feveral conftellations thereof. Thus commencing botanift and aftronomer, without knowing what he was about.

At the fame time, *Otto Guericke*, famous for the invention of the *air-pump*, the *hemifphere*, &c. was bourguemaiftre of the city. To him M. *Homberg* applies himfelf to learn experimental philofophy: and that gentleman, tho' otherwife myfterious enough, either reveal'd all his fecrets, in favour of his genius, or could not conceal them from his penetration.

His friends feeing him thus eftrange himfelf from the Bar, thought to fix him by marriage; but perceiving the defign, he betook himfelf to travel, and went for *Italy*. At *Padua* he fpent a year, in the ftudy of medicine, and particularly of anatomy and plants. At *Boulogne*, he work'd on the ftone of that name, and learn'd the fecret thereof, which was almoft loft. At *Rome* he employ'd himfelf with *M. A. Celio* in grinding large telefcope glaffes; not neglecting any of the arts of that country, painting, fculpture, and mufic. Hence he pafs'd into *France*; and thence into *England*, where he work'd fome time with the great Mr. *Boyle*, whofe laboratory was then one of the beft fchools of philofophy in *Europe*. From *England* he went to *Holland*, where he perfected himfelf in anatomy, under the famous *de Graeff*. And after a vifit to his relations, now reinftated in *Saxony*, he took the degree of doctor of phyfic at *Wittembourg*.

But his pilgrimages were not yet at an end; he was now bent on a vifit to the *Virtuofi* of *Germany*, and the *North*; and as by this time he had got a confiderable ftock of phyfical curiofities, he began to think of fettling a traffic, and getting others in exchange for them. Accordingly, he applied to *Balduinus*; then to *Kunkel*, at *Berlin*, and procured the fecrets of their refpective *phofphori*. Metals now demanded his attention; and he travel'd thro' *Saxony*, *Bohemia*, *Hungary*, and *Sweden*, to view the mines.

At *Stockholm*, finding a chemical laboratory juft eftablifhed by the king then reigning; he wrought fome time therein, with *Hierna*, phyfician to the prince; and contributed greatly to the firft fuccefs of the new eftablifhment. Here he was often applied to on occafion of the difficulties which divided the learned; and the journals of *Hambourg*, printed in *High-Dutch*, are

The *Philosophical Transactions* of the royal society contain many valuable things in chemistry; chiefly, of those two excellent authors, *Cox* and *Slare*; a great part of which are omitted in *Lowthorp*'s abridgment. Those authors write nothing but what they have thoroughly examined; and deserve well to be studied, both on account of their experiments, and their reasonings.

The *History and Memoirs* of the royal academy of sciences are likewise enriched with a great number of the most curious, and exquisite pieces in

are full of memoirs composed by him on such occasions. His next remove was into *Holland*, and from thence into *France*, to pick up what had before escaped him.

From *Paris*, at the earnest sollicitations of his father to put an end to his travels and settle among his friends, he was upon the point of returning to *Saxony*; and had even taken coach, with that view, when a messenger came to him from M. *Colbert*, in the king's name. That great minister making him very advantageous offers to settle there; after a little time taken to consider of the matter, he accepted them, renounced his religion, and commenced catholic in 1682; for which he was disinherited by his father.

To avoid being drawn into the vain search of the philosopher's stone, by a chemist, with whom he was employ'd in the laboratory of the *Abbe de Chalucet*; and for some other reasons; he went to *Rome* in 85; where he practised physic with good success: but after a manner little known in that country.

His quality of doctor of *Wittemberg* he made no account of; but practised merely on the foot of a physician by genius. His great sagacity in discovering the causes of diseases and the remedies required, by nice reasoning, served him instead of experience. After a few years he returned to *Paris*; and in 1691, upon the *Abbé de Bignon*'s having the direction of the royal academy, he was adopted into the same, and put in possession of the laboratory of the academy. And 'twas chiefly his industry and address in furnishing matter for the meetings, that kept up the company, till its revival in 1699.

The duke of *Orleans*, since regent of the realm, having an inclination to study chemistry, and experimental philosophy: his preceptor the Abbé *de Bois*, since cardinal, recommended to him M. *Homberg*, as his guide. In 1702, that prince took him into his family, in that quality, allow'd him a considerable salary; and provided him the most magnificent, and best appointed laboratory, chemistry had ever known. Here the princely chemist came daily, receiving the instructions of his tutor with the utmost ardor, and frequently preventing them; entring into all the detail of the operations, performing them himself, and even inventing new ones; so that the master has often stood astonished at his disciple.

The same year, his highness procured M. *de Tschirnhausen*'s large burning-glass from *Germany*; a new kind of furnace, of which M. *Homberg* made a noble use. He married a daughter of the famous M. *Dodart*, in 1706: some years after which, he fell into a dyssentery; which was cured, and returned again from time to time; till at length, in the year 1715, it put an end to his life.

He never published any express work, or volume in form: His *Essays*, or *Elements of Chemistry*, were begun to be printed in the memoirs of the academy; and the rest of them were found in good order, and fit for the press, at his death. Beside which, there are a great number of lesser pieces, on divers occasional subjects, dispersed throughout the same memoirs: none of which but open new views, and shine with their peculiar light; and there are many of them, which, with the addition of common matters, others would have made whole books of. His way of expressing himself was simple, precise, and methodical; and he was as far from the natural ostentation of the chemists, as from their mysteriousness, and obscurity.

the ſame kind, by Meſſ. *Lemery* and *Homberg* above-mentioned; as alſo Meſſ. *Geoffroy*, *Lemery* the younger, *Boulduc*, &c.

Theſe authors we would have read in the ſame order wherein they are here enumerated: and of all the writers in chemiſtry, tho' almoſt infinite in number, theſe few are all we can heartily recommend for the ſtudy thereof.

PART

# PART II.

# THEORY OF CHEMISTRY.

*CHemiſtry is an Art, whereby ſenſible bodies contain'd in veſſels, (or at leaſt capable of being contained therein and render'd ſenſible;) are ſo chang'd, by means of certain inſtruments, and eſpecially fire, that their ſeveral powers, and virtues are thereby diſcover'd; with a view to the uſes of medicine, natural philoſophy, and other arts and occaſions of life.* Chemiſtry defined.

This definition may appear prolix, and circumſtantial; but with our utmoſt endeavours, we could not frame a ſhorter, that would expreſs the full ſcope, object, and inſtruments of chemiſtry, ſo as to diſtinguiſh it from every other art: a thing, all the writers of chemiſtry have hitherto ſtumbled at. For chemiſtry cannot juſtly be call'd *the art of reſolving bodies*, as *Regius*, *Paracelſus* and others define it; ſince, on ſuch footing, it would not differ from mechanics, which certainly reſolves bodies. Nor is the matter mended, by ſaying it is the *art of analyzing bodies by fire*, as *Helmont* has done; nor *by ſalt*, as others would have it: Theſe definitions including only a part, inſtead of the whole. And with as little propriety is it term'd *the art of ſeparating the pure from the impure*; becauſe it compounds as well as ſeparates, and frequently mixes the impure with the pure.

To ſhew that the definition of chemiſtry, which we have above deliver'd, is juſt, and adequate; we ſhall take it to pieces, and explain every part thereof: And ſuch explanation will comprehend the whole *Theory* of chemiſtry.

*An Art,* *Chemistry*, then, *is an art*; and *art* is defin'd, by the philosophers, a habit of the mind, operative, or effective, according to right reason; or, more intelligibly, a habit of the mind prescribing rules for the due production of certain effects; or, still more sensibly, the introducing of a change in bodies, from some fore-knowledge or design in a person, call'd an *artist*; in whom resides a principle, or faculty of acting.* To illustrate this by an example: a block of marble being given to a sculptor, whereof to form a statue of *Mercury*, if the man can do the thing, he is an artist; and that principle within him, whereby he is enabled to perform it, is the craft or *art*; which, apparently is no other than the knowledge he has how to make the statue out of the marble. To this end it is necessary that he have a just idea of *Mercury*, who is describ'd as a handsome, alert youth, with wings, *&c.* But that is not enough; for every learned man knows this, yet cannot make the statue: he must therefore, know how the thing is to be effected, and by what assistances; particularly, that in any piece of marble all forms are concealed; and therefore, that from the present block he is only to take away every thing redundant, as in the face, hands, *&c.* but to add nothing. He must know farther, in what manner this retrenchment is to be made; and *how much* to be taken away: nor is this sufficient; but he must understand by what instruments it is to be done; as the *mallet*, *chissel*, &c. and how to direct these instruments. All which must the chemist know, in his art, as well as the statuary.

*Which changes bodies.* We add, in our definition, that chemistry is an art *which changes bodies*: Whence it appears, that body is the object of chemistry. Now we call *body* whatever is extended, solid, hard, impenetrable, moveable, figurable, ductile, *&c.* And such body chemistry regards as its object; yet all body has not the privilege of being this object: For bodies we observe are either *sensible* or *insensible*.

*And particularly sensible ones.* The *sensible* are such as affect our senses; or have such a determinate magnitude, figure, and distance, with regard to our organs of sense, as to produce changes therein, whose effects come under the notice of the mind.

*Insensible* are such as do not fall under our senses; that is, such as are either so small, or so remote, that their action on the organ works no notable change. Thus the air, wherewith we are every way surrounded, is full of an infinite number of heterogeneous corpuscles, which have indeed an effect on our bodies; but 'tis such an one as our senses take no cognizance of.

* The less curious of our readers, may not care to enter so far into the metaphysical origin of chemistry. But where so spacious a superstructure is to be raised, one cannot well go too deep for a foundation. Our author's oeconomy here is admirable: His definition is an epitome of his whole book; or the book a paraphrase on the definition. He first gives us the whole in miniature; and then takes every part, in its order, and enlarges it to its proper bulk. When he comes to *body*, that complex thing, the reader would imagine he had lost the view; but, after dilating, and opening it by degrees, till he has discovered all it contains, he returns, and goes thro' the rest. This hint, will let the reader into a method, beautiful beyond expression.

Now,

Now, chemiſtry only regards *inſenſible bodies* as its objects, ſo far as they are *capable of being rendered ſenſible*; whence, in effect, it conſiders none but ſenſible bodies.

It muſt be added, that even all ſenſible bodies are not objects of chemiſtry; but only thoſe which are capable *of being contained in veſſels*. Thus the *Moon*, tho' a ſenſible object, is no object of chemiſtry, becauſe not capable of being contain'd in veſſels. But there are abundance of inſenſible bodies which may be render'd ſenſible, and included in veſſels; as is evident from chemical ſpirits; which often are only an inſenſible aura or exhalation, that would fly away unperceiv'd; but being caught and collected in alembics and retorts, come under the notice of our ſenſes. *Contained in veſſels.*

The objects therefore of chemiſtry are of two kinds, *viz.* any *ſenſible* body fit to be included in veſſels; and any *inſenſible* body capable of being render'd ſenſible, and included in the like manner.

Theſe objects chemiſtry conſiders only ſo far as they diſcover themſelves by their effects: Thus, what gold is in it ſelf, no body knows; but what it does, we all know; and ſo far as it produces certain effects, ſo far we underſtand its nature, and no further.

In treating of *bodies*, we uſually divide all ſenſible nature into three claſſes, which the chemiſts call *kingdoms*, viz. the *foſſil*, *vegetable*, and *animal* kingdom. *Body divided into kingdoms or claſſes.*

This diviſion, which at firſt ſight appears groſs and inaccurate, is, in reality, very ſubtile and adequate; being taken from the three different manners of growth which obtain among bodies. For all bodies either grow adhering to the earth, in ſuch manner, as that there is no apparent diſtinction of parts containing, and contained, *i. e.* of veſſels, and juices circulating in them; which are called *foſſils*: Or they grow adhering to the earth, ſo as that there is a real difference of veſſels and juices diſcernible therein; which are *vegetables*: or laſtly, they grow without adhering to the earth at all; and are called *animals*.

Each of them we ſhall conſider in its order, and firſt

Of

# Of FOSSILS, or the Fossil Kingdom.

Fossils. WE have already divided bodies into three classes; to one or other of which, all of 'em, the primary elements, fire, water, air, and earth excepted, may be referred.

Defined. We begin with the most simple, and inorganical, *viz. fossils*; the general notion whereof is comprized under the following definition: *A fossil*, sometimes also called mineral, *is a sensible body generated and growing, in and of the earth, whose consistent parts are so simple and homogeneous, that there is no apparent distinction of vessels and juices; or between the parts and the whole.*

This character holds of fossils, and of them alone: Thus gold, silver, and the other metals, antimony, salts, sulphur, stones and other minerals, really grow *fixed to the earth*; and in such manner, that if they be divided into the minutest parts, they will every where appear the same similar solid matter, without any *shew of vessels and humours*. And thus, should it be urged that spirit of wine must, on this footing, be a fossil, because homogeneous in all its parts, and exhibiting no distinction of vessels and juices; the answer is obvious: since spirit of wine, as such, is not *generated of or under the earth*; neither is it a *vegetable*; that denomination including the whole compages or structure, out of which the spirit of wine is prepared. Or, if a second should argue, that *antimony* should then be no fossil, since it contains a sort of heterogeneous sulphur: 'tis answered, that as to our senses, 'tis in all respects a fossil; since whatever portion you take thereof, 'tis the same indistinguishable matter, and has all the characters of *antimony*.

Fossils divided. Now *fossils* are either simple or compound: *Simple* are such whose parts, howsoever divided, are all of the same nature, *i.e.* of the same gravity, magnitude, figure, hardness and mobility: As quick-silver, which tho' divided to infinity, is found every where the same in all these respects.

*Compound* are those which may be divided into different, or dissimilar parts; or, whose parts are unlike in magnitude, figure, hardness and mobility: As antimony, which may be resolved by fire, into sulphur, and a metalline part.

Simple fossils. The SIMPLE FOSSILS are, 1. *metals*, 2. *salts*, 3. *stones*, both vulgar and precious; and 4. *earths*.

Compound fossils. The COMPOUND FOSSILS are, 1. all *sulphurs*, 2. *semi-metals*, or what we properly call *minerals*, 3. bodies combined out of the preceding fossils, either simple or compound.

*Metals* making the primary head in fossils, we shall treat of 'em in the first place.

*First*

# *First Class of Fossils.*

## METALS.

A *Metal is a simple, fossil body that fuses, and becomes fluid by fire, and by cold coagulates and hardens into a solid mass, capable of distending under the hammer.* Metals defined.

We call it *simple*, since it may be said of every the minutest particle of a metal, *e. gr.* a grain of gold, that *it is gold*, or has all the properties of gold. *Fusible by fire*, that is, when exposed to a great fire, it dissolves into parts which are easily moveable among themselves, or perhaps are in actual motion. *Fixed*, i.e. bearing the fire without flying off in vapour: tho' 'tis only to a certain degree that metals are fixed; for by the large burning glasses of Mess. *Tschirnhausen* and *Villette* all metals readily evaporate.

Such is the proper idea of a *metal*, which is no ways applicable to any other body in nature: for a diamond, tho' a simple body, is not *fusible* in the fire, nor capable of being *stretched under the hammer*. And salt, tho' dissolvable by fire, is not *malleable*, but breaks under the hammer. It may be added, that there are certain woods which yield in some measure to the hammer; but then they fall to dust in the fire: and so of the rest.

We find but six METALS in all nature, viz. *gold, lead, silver, copper, iron*, Divided. and *tin*: tho' to these the chemists usually add a seventh, *viz. mercury* or *quick-silver*; but with some impropriety, as it has not all the characters of a *metal*, nor scarce any thing in common with the other metals, except weight and similarity of parts. Thus it is neither dissoluble by fire, malleable, nor fixed; and in effect, it seems to constitute a peculiar species or class of fossils. But the chemists, tho' at first they seem to have been overseen, yet have somewhat to alledge in their behalf: for mercury, they hold the basis or next matter of all metals; or, if you had rather, metals themselves are only mercury fixed: and thus by only throwing in sulphur, its parts are bound together, and form a metal. Hence, as 'tis only a circumstance that is wanting to make quick-silver a metal; so near an affinity may well warrant the calling it by that Name.

These metals, have obtain'd a kind of *apotheosis*, or translation into heavenly bodies, or planets: thus gold is called *sol* or the *sun*; silver *luna* or the *moon*, &c. which proceeded, no doubt, from some similitude, which the ancients imagined between the planets and the metals.* The planets we know took their names from hero's and deities; and the same names came in time to be given to metals. Metals translated into heavenly bodies.

* Thus, in the *table of emeralds* ascribed to *Hermes*, 'tis frequently repeated that the *metals below are the same as those above.*

And we read of an antient *Coptic* Inscription near the city *Memphis* in these terms; *There is heaven above, and heaven below; stars above and stars below: every thing that is above is below.*

Nor

*The ground thereof.*

Nor does the thing appear prepoſterous, if cloſely attended to: for that vigorous brightneſs is not leſs conſpicuous in *gold* than in the *ſun*: the white colour of *ſilver* agrees very well with that of the *moon*: the glittering fierceneſs of *Mars*, bears a near reſemblance to that of red-hot *iron*: the pale livid aſpect of *Saturn* is well repreſented by the colour of *lead*: and the variety obſerved in the appearances of *Venus*, is imitated by the different colours of *copper*; and ſo of the reſt.

The *caballiſts*, and after them the aſtronomers, uſe the ſame characters to denote the planets, as the chemiſts do for the metals; and hence the ſcale of the ſeven planets in heaven, and of the metals on earth, is the ſame.

*The characters they are denoted by.*

The characters which denote the metals, and ſome other chymical ſubjects, are theſe.

| | | |
|---|---|---|
| ☉ Gold | or | *Sol*, |
| ☾ Silver | | *Luna*. |
| ♀ Copper, | | *Venus*. |
| ♂ Iron, | | *Mars*. |
| ♃ Tin, | | *Jupiter*. |
| ♄ Lead, | | *Saturn*. |
| ☿ Quick-ſilver, | | *Mercury*. |
| ✝ Vinegar | | Corroſiveneſs. |
| ♁ Antimony, | | The king's bath. |

Theſe characters appear to have been in uſe among the moſt ancient chemiſts. They are ſaid to be of a thouſand years ſtanding; and to have been originally taken from the religion of the *Perſians*.

'Tis certain, there have always been two ways of writing: the one by *letters*, arbitrarily pitch'd on to denote things; as that in uſe among us: the other by *characters*, or images of the things denoted, called *hieroglyphicks*: ſuch was that of the ancient *Egyptians*; who to denote a dog, put a dog's-head; for a ſtout man, a lion; for a perfect thing, a circle, &c. which manner ſtill obtains among the *Chineſe*, and hence that difficulty, ſo much complain'd of, in learning their language; the number of their characters being ſo great, that even the moſt learn'd among their *Mandarins* ſcarce underſtand a twentieth part of 'em. The images they uſe are ſuch as we ſometimes ſee in our porcellane, or china-ware, which thoſe people readily read.

*Rationale of the characters.*

This hieroglyphic or caballiſtic manner of writing was adopted by the chemiſts; who denoted their metals by characters that ſeem drawn from the very depths of chemiſtry, and hold forth the intimate nature of the metals themſelves. Their firſt character

☉ *Gold* is a circle, with a point in its centre: now the circle, 'tis notorious, is a ſymbol of perfection, and ſimplicity; and was always uſed as ſuch by the ancient caballiſts: in reality there is no figure more ſimple, uniform, or perfect than this; it comprehends the greateſt ſpace under the leaſt ſuperficies; and all the *radii* drawn from its centre to its circumference are equal; properties which correſpond very aptly to the ſun in the heavens, and to gold on the earth. For

For gold is the moſt ſimple of all metals; every particle thereof being of the ſame nature with the whole: and at the ſame time it is the moſt perfect; as being the heavieſt, and including the greateſt quantity of matter under the leaſt ſurface. Its nature therefore is well denoted by the figure above deſcribed.

☾ Is the character ſignifying *ſilver* on earth, and the *moon* in the heavens. This figure would be a perfect circle, if the inner part were properly applied to the outer: thus of ☾, CC, would ariſe O.

Now, the chemiſts all agree, that ſilver is half-gold; or, that part of it is gold; only, that part lies hid. Accordingly, its character denotes gold half perfected; for, ſay they, if you can but turn the gold-part that lies hid in the ſilver, outwards; your ſilver will be converted into gold. Thus gold being accounted the moſt perfect of all metals, ſilver comes the neareſt thereto; conſequently 'tis a ſort of ſemi-gold. Monſ. *Homberg* ſhews, that pure ſilver, perfectly purg'd of all gold, being kept a long time in the fire, always gains a little portion of gold, *i. e.* part of it becomes gold.

♀ *Copper*, is a circle, with a croſs underneath; and denotes that the body or baſis is gold, tho' join'd with ſome corroſive menſtruum.

For a croſs, + is the character whereby all corroſives, as fire, *aqua fortis*, vinegar, and other ſharp diſſolvents, were denoted by the ancients; thoſe being things that uſe to torment, and as it were *crucify*: now, all the adepts allow copper a noble metal, only debaſed by a ſharp, corroſive, or arſenical poiſon adhering thereto, which is capable of deſtroying men; and which taken away, the copper is left gold. Accordingly copper, of all metals, ſilver only excepted, is allowed to come neareſt gold.

♂ *Iron*, this character likewiſe denotes gold at the bottom; only its upper part too ſharp, volatile, and half corroſive; which being taken away, the iron would become gold.

Accordingly, the chemiſts hold that iron comes neareſt to gold after copper. 'Tis *Baſil Valentine*'s tenet, that *Mars* and *Venus* together make *Sol*. The ſame author introduces iron by way of proſopopœia, ſaying, if you put off my cloaths, *i. e.* the corroſive, you will come at my ſoul, *i. e.* the intrinſic nature of iron.

♃ Tin is held to be one half *luna*, or ſilver, and the other half corroſive; which is denoted by the ſemi-circle, and the croſs added thereto. ☾+ In effect, it comes the neareſt of all metals to ſilver, and has moſt of the properties of it, excepting weight: and they agree in this particular circumſtance, that they both grow bitter in acids; which no other metals do. Mr. *Boyle* is even of opinion, that tin and ſilver are the ſame body; only that there is a deal of corroſive ſulphur in the former: hence ſilver and tin fuſed together, mix and cohere ſo intimately, that there is ſcarce any ſeparating 'em, even by lead.

♄ *Lead* appears to be the character of tin inverted, with the corroſive paſſing through the middle. It is variouſly wrote; has frequently a double croſs $\overset{+}{\text{♄}}$, to ſhew that it corrodes on all ſides.

Accordingly, all metals are deſtroyed by lead; gold and ſilver only excepted: and hence this character is here uſed to denote it principally as a

corrosive, tho' the middle part bears some resemblance to *luna*, or silver; as there is a real correspondence in colour, taste, &c. between lead and silver.

☿ *Quicksilver* evidently shews gold in the middle, or body of it, silver at top, or in the face, and a corrosive at bottom: accordingly all the *adepts* say of mercury, that it is gold at heart, whence its heaviness; that its outside is silver, whence its white colour: but that there is a pernicious, corrosive sulphur adhering to it, denoted by the cross; that if its brightness, and its corrosive could be taken away, it would remain gold; that the quantity of sulphur is here so great, as to render it wholly combustible by fire; that the more 'tis burnt, the nearer it comes to gold; and that were it perfectly calcined and purified, and its colour changed, it would be gold.

The like is asserted by M. *Homberg*; viz. take out the corrosive sulphur denoted by +, and the whiteness signified by ☾, and mercury, will be ☉ gold. And hence that maxim upon mercury: Strip me of my clothes, and turn me inside out, and all the secrets of the world will come forth.

♁ *Antimony*, is a circle, denoting the body of gold; to which a cross is added, to shew it a corrosive; and because the corrosive prevails, the cross is placed at top. Accordingly antimony is the destruction of all metals, except gold; the other five, with stones, salts, &c. being all lost in the corrosive.

Again, the character of antimony is the same with that of *tellus*, or the earth; as being a sort of chaos or universal body; and accordingly *Basil Valentine* calls it *omne in omnibus*.

We now see why the ancient chemists had recourse to a kind of images of bodies, and directed their followers to seek for all things, in the grand world; as is well shewn by *Pantaleon* and *Suchten*. The truth is, something obtains in the planets and heavenly bodies, very like what we see in minerals; so that there is a real foundation for the allusion.

*Distinguishing character of metals.*

The common radical character of metals is, that of all known bodies they are the heaviest: by Dr. *Halley's* experiments, the weight of gold to that of glass is determined to be as 7 to 1; and the weight of tin, tho' the lightest of all metals, to that of gold as 7 to 19; which considerably surpasses the weight of all stones, marbles, gems, and other the most solid bodies; as appears from the tables of specific gravities.

*Their weight.*

The lightest of all metals, therefore, is six times as heavy as water: and there is no body, beside a metal, whose weight will hold that excess. So that to the definition of a *metal* above laid down, we might add this circumstance, that it is *at least six times heavier than water*.

This being laid down, it appears from the ancient atomical philosophy, so nobly retriev'd by Sir *Is. Newton*, that the matter of bodies is proportionable to their weight; or that the weight of any body is as its substance. Now, this holds peculiarly of metals, which are so perfectly distinguish'd from other bodies by their weight, that no body but a metal can have the weight of a metal.

The

The royal ſociety furniſh us with various experiments in this kind: the weight of the ſeveral metals and other ſolids, they have examin'd hydroſtatically, by weighing 'em bulk againſt bulk, in air and in water; and the weights of the fluids, by weighing an equal portion of each. By ſuch experiments they find, that taking the ſame weights of water and gold, the bulk or magnitude of the former is to the latter as *19636* to 1000: conſequently, that the weight of gold is to water nearly as 19 to 1.

The ſpecific weights of the ſeveral metals thus determined, ſtand as follows.

| | | | |
|---|---|---|---|
| Gold | *19636* | Iron | 7852 |
| Quickſilver | 14019 | Tin | 7321 |
| Lead | 11345 | Stone | 2000 |
| Silver | 10535 | Water | 1000 |
| Copper | 8843 | Air | $1\frac{3}{17}$ |

But it is to be obſerv'd that ſuch weights cannot be aſcertain'd to geometrical exactneſs, unleſs we know the juſt proportion of the heat and expanſion of the metals; for the ſame degree of heat will rarify one metal conſiderably more than another. Add, that there will ſome inaccuracy ariſe from the air; its weight to that of gold, is here laid down as 1 to 19; but this is only to be underſtood of pure fine air, ſuch as that about *London* or *Paris*: groſſer air, as that in moſt parts of *Holland*, is found to gold as 1000 to 1. If what Mr. *Boyle*, and M. *Mariotte* contend for, be true, *viz.* that air is capable of being condenſed *ad infinitum*, it may even be made heavier than gold; as by being compreſs'd above 19 thouſand times, it muſt be: but this is chiefly conjecture.

This doctrine of ſpecific gravity of metals is of the utmoſt uſe in the buſineſs of mines: for if in digging, you meet a glebe or mineral, whoſe weight is 6 times as great as that of water; you may ſafely conclude there is metal therein. Again, if the gravity of the body found be to that of water as 18 to 1, you may reſt ſecure there are at leaſt, $\frac{4}{15}$ parts of gold in it: for as there is no body heavier than gold, nor any body that comes nearer the weight of gold than pure quick-ſilver, whoſe weight is to that of water as 14000 to 1000, or as 14 to 1; it follows of neceſſity, that the body, whoſe weight is as 18 to one, muſt have $\frac{4}{15}$ parts of gold in it. And if the other parts be not quick-ſilver, but ſome other body, the proportion of gold therein will be ſtill greater.* *Knowledge thereof neceſſary in digging mines.*

Gold,

* The origin and formation of metals is ſomewhat obſcure; tho' we have two or three ſyſtems to account for it: the firſt ſuppoſes the metalline particles to have been form'd from the beginning, and ranged by the law of gravity, in regular ſtrata, next the center of the earth; from whence they have ſince been raiſed by the action of the central heat, up toward the ſurface, and depoſited there in all parts of the globe. Such is the opinion likewiſe of many of the modern naturaliſts, as of *Des Cartes*, Dr. *Woodward*, &c. The *ſecond* ſets aſide this pre-exiſtence, and ſuppoſes metals to be form'd

Gold, then, being the heavieſt and nobleſt of all metals, we begin with gold, and proceed to the reſt in the order, wherein their gravity places them.

*GOLD.*

form'd, or generated *de novo*, by the occaſional mixture of certain matters, wherein nothing of a metalline nature was before contained.

This opinion, which is the moſt ancient, and withal the moſt common, is confirmed from the inſtance of artificial metals. M. *Geoffroy*, from a mixture of ſulphur, a vitriolic ſalt, and a clayey earth, brought an iron, which he maintains to be a new production, or a compoſition of thoſe principles. He adds, that the aſhes of all vegetables afford iron, which it would be hard to ſuppoſe lodg'd in the plant it ſelf, and muſt rather be deem'd the effect of the fire in calcination. Again, clay does not ſhew the leaſt ſign of any metal, work it how you will, without mixing; but add linſeed oil to it, and by fire you will have a metal, which is no other than real iron. In effect there are divers other matters, which give no ſuſpicions of being metalline, and yet afford a ponderous ſubſtance, to which fire gives all the properties of iron; ſo that 'tis probable, metals are only form'd by the aſſemblage or combination of certain matters or principles; much as ſulphur is, by the admixture of an inflammable principle, with a vitriolic ſalt. When theſe matters, which we may ſuppoſe continually circulating thro' the pores of the earth, meet with an earth which has an affinity with 'em; they ſtick therein; and thus ariſe *mines*, *metalline veins*, &c.

What farther confirms this, is, that if earths or ſtones of different kinds be put in a mine, different metals will be produced therein. Thus *Albertus Magnus* remarks, that the ſame ſtamen of gold by adhering in different glebes has degenerated into ſilver: and ſeveral other authors affirm, that by changing the earth of a mine, the metal becomes changed.

M. *Lemery*, the younger, attacks this ſyſtem with great addreſs: the iron in the aſhes of plants, he maintains, really exiſted in the plants themſelves; being rais'd in their veſſels, along with the juices of the earth: and for M. *Geoffroy*'s artificial iron, he avers, that its ingredients do all really contain iron in themſelves; and mentions the operations whereby it may be extracted.

To this M. *Geoffroy* anſwers, that the quanty of iron procured from each of the ingredients, ſeparately, is infinitely leſs, than when they are mixed; ſo that the mixture ſtill produces metal. Beſide, M. *Lemery* uſes oil in the operations; now oil is not a ſimple ſubſtance, but is compos'd of earth, an acid, and a ſulphurous part, which are the very three principles required to the formation of iron: ſo that in all probability, the fire, by more cloſely aſſembling, and uniting theſe principles, makes the iron it was thought to extract; the means uſed to procure the ſuppoſed iron from the ingredients being preciſely the ſame with thoſe whereby iron is compoſed. And thus does the noble ſtrife ſtand, as it were *in equilibrio*; to be determin'd as new lights, and future diſcoveries, ſhall direct the ſcale.

In the mean time we may add, that iron is not only producible, by the mixture of different ſubſtances, wherein there was no appearance of iron before; but even in the ſame, ſimple ſubſtance, by mere force of fire: thus Mr. *Boyle* relates, that he had a ruddy, mineral powder, which the loadſtone had not the leaſt effect upon; but which being wetted with linſeed oil, and then kept glowing hot in a crucible for two hours, turn'd blackiſh, and would then adhere to the ſame load-ſtone, almoſt as readily as if it had been a heap of iron filings. But, continues he, the operation of the fire, perhaps, contributed to the change as much as the linſeed oil; for ſome of the ſame red powder being kept ignited in a crucible, without the liquor, afterwards appear'd magnetical. *Mech. Prod. of Magnet.*

The *third* opinion is that of M. *Tournefort*, who holds that metals have their origin from *ſeeds* or *eggs*; that their production and growth is no more than an opening, or expanſion of the ſeminal parts; and in a word,

# GOLD.

THE first *property*, or *characteristic* of gold, is, that it is the heaviest of all bodies in nature. We have obferv'd, that it weighs nineteen times more than water, taking bulk for bulk: and this property is infeparable from it; no affured method having ever yet been found out to render gold more or lefs heavy *. Add, that whereas all the other properties of gold may be imitated, its weight alone is inimitable. Whereever therefore we find the fpecific gravity of gold, *i. e.* nineteen times the weight of water; there, beyond all contradiction, is real gold: So, if I have a mafs of matter heavier than mercury, it is fure that there is a fhare of gold in it; there being, as already obferved, no intermediate body between mercury, and gold; *e. gr.* no body, which is, to gold as 16, or 18, to 19.

*Gold.*

*Its fpecific gravity.*

*Inimitable.*

word, that they are organized bodies, and have veffels with juices circulating therein.

This Theory, which is chiefly founded on a fuppofed analogy between the feveral works of nature fome authors are fond of, we fhall have occafion to fpeak of more fully hereafter.

Metals are chiefly found in mountains; but whether it be that they grow more there than in plains, or only are eafier come at, and more commodioufly dug, does not appear. The figns by which they difcover a Mine, are, the mineral tafte of the water; the exhalations it emits; the difference between the face of the foil there, and in the adjacent parts, in frofty weather; and laftly, barenefs of grafs, and the pale hue thereof.

Mines are fometimes open'd e'er the metals be quite form'd; and are fhut up again, to give time for their coming to maturity. Others, after they have been quite exhaufted, and have lain by for feveral years, are found as rich again as ever: inftances of this Mr. *Boyle* gives us in tin mines; *Agricola*, *Boccacius*, &c. in lead mines; *Pliny*, *Strabo*, and *Cæfalpinus* in iron mines: the like accounts Mr. *Boyle* mentions of filver mines; but he could hear of none of gold mines. It is likewife found, that the ore of lead, and other metals being wrought, and laid by in heaps, does, in tract of time, become impregnated anew. Add, that at the famous gold mine at *Cremnitz* in *Hungary*, after a vein is almoft fpent, they caft in large quantities of earth; which after fome years affords gold as before: and at *Corbac* in *Weftphalia*, they melt gold out of their heaps once in four years, in which time it is generated afrefh.

The veins of metals always follow one conftant direction: if they run fouthwards, they never decline either to the eaft, or weft: and if they happen to be interrupted, as by rivers, &c. they refume their former direction on the other fide. Indeed there are fome, very rare, inftances of a vein's taking a new direction: but then it perfifts inviolably therein. *Nouv. Cours de Chymie.*

* My Lord *Bacon*, indeed affirms, that he had the fecret of making mercury penetrate gold, fo as to increafe its weight very confiderably, without any addition to its bulk. Whether or no his procefs will anfwer, we cannot fay: the experiment is too coftly to make. But there is nothing improbable in the thing. For gold, for all its great weight, is known to be very porous: water may even be forc'd thro' its interftices, and why not mercury? Sir *I. Newton* computes, that gold has even more pores than folid parts. *Optic.* p. 242.

Whoever

Whoever, therefore, would make gold, muft be able to add to the weight of other metals; fo as to render them equiponderant with gold.

*To prove its truth.* Hence, if any fraudulent alchemift fhould obtrude a metal on you for gold; take a piece of pure gold, hang it by a hair or thread to a nice balance, and hang an equal weight of the fufpended gold by another hair, to the other end of the beam; then immerging both pieces in water, if the alchemift's gold be pure, the water will retain both pieces *in equilibrio*, as before; otherwife, the adulterate metal will rife, and the pure defcend.

*Its ductility, and malleability.* The *fecond property* of gold is, that of all known bodies, it is the moft ductile, and malleable; and, of all bodies, its parts cohere with the greateft obftinacy *.

Our gold-beaters, and wire-drawers, furnifh us with abundant proofs of this property: they every day reduce gold into leaves or *lamellæ* inconceivably thin; yet without the leaft aperture, or pore difcoverable even by the microfcope: a fingle grain of gold may be ftretched under the hammer into a leaf that will cover this houfe; and yet the leaf remain fo compact, as not to tranfmit the leaft ray of light; nor even admit fpirit of wine, the fineft and fubtileft fluid in nature, to tranfude, or pafs thro' it.

Dr. *Halley* took the following method to compute the *ductility* of gold: He learnt from the wire-drawers, that an ounce of gold is fufficient to gild, *i.e.* to cover, or coat, a filver cylinder of forty-eight ounces weight; which cylinder may be drawn out into a wire fo very fine, that two yards thereof fhall only weigh one grain; and confequently ninety-eight yards of the fame wire only forty-nine grains. So that a fingle grain of gold here gilds ninety-eight yards; and of courfe the ten thoufandth part of a grain is here above one third of an inch long.

And fince the third part of an inch is yet capable of being divided into ten leffer parts, vifible to the naked eye; it is evident that the hundred thoufandth part of a grain of gold may be feen without the affiftance of a microfcope.

Proceeding in his *Calculus*, he found, at length, that a cube of gold, whofe fide is the hundredth part of an inch, contains 2,433,000,000 vifible parts: and yet, tho' the gold wherewith fuch wire is coated, be ftretch'd to fuch a degree, fo intimately do its parts cohere, that there is not any appearance of the colour of the filver underneath †.

This

* Sir *I. Newton*, fhews, that the primitive, or component particles of all bodies, are hard: that they are only laid together; and that the caufe of their cohefion is fome attractive force fuperadded to 'em, whereby they unite together into larger particles, and thofe, at length, into fenfible maffes. Now, if the compofition be fo, as that the particles, under the circumftances of their attractive or cohefive force, are liable to flide eafily on one another, the body becomes ductile, or malleable, or foft. *Newt. Optics.* p. 370.

† Mr. *Boyle* examining fome leaf-gold, found, that a grain and a quarter's weight took up an area of fifty fquare inches: fuppofing, therefore, the leaf divided by parallel lines $\frac{1}{100}$ of an inch apart; a grain of

This tenacity, or force of cohefion in the parts of gold, which appears fcarce lefs than infinite, depends altogether on its being freed from fulphur: for mix but one fingle grain of fulphur with a thoufand grains of gold, and the mafs ceafes to be malleable, till all the fulphur have been evaporated. And hence we have a ftrong prefumption, that the lefs tenacious metals, tin, copper, and iron, contain a great deal of fulphur. *Depends on its being free of fulphur.*

The immenfe divifibility of gold is learnt from another experiment: for example, take a pound of filver, and fufe it with a fingle grain of gold; the gold will diffufe itfelf equally through every minute particle of the filver; fo that taking a grain of the mafs, and diffolving it in *aqua fortis*, you will find a quantity of gold fall to the bottom, which has precifely the fame ratio to the grain of gold, as the gold in the mafs had to the whole mafs.

The third *character* of gold is to be the moft fixed of all bodies, *i. e.* to lofe leaft in the fire. *Its fixednefs.*

Natural bodies are reducible to two claffes, *fixed* and *volatile*: the firft, fuch as bear the utmoft violence of the fire, without evaporating, or lofing any thing of their weight: the fecond, fuch as fly away in fume. Now, of all metals, gold and filver alone are accounted fixed; but gold much more fo than filver.

*Gafto Claveus*, the *Prince* of *Mirandula*, and others, have made experiments to this effect: A quantity of very pure gold being placed in the eye of a glafs-furnace, wherein was a very great flame, and of confequence a

of gold will be divided into five hundred thoufand minute fquares, all difcernable by a good eye. For gold-wire, the fame author fhews, that an ounce of gold drawn out therein, would reach 155 miles and an half. *Nat. of Effluv.*

But M. *Reaumur* has carried the ductility of gold to a ftill greater length: A gold-wire, every body knows, is only a filver one gilt. This cylinder of filver, cover'd with leaf-gold, they draw thro' the hole of an iron; and the gilding ftill keeps pace with the wire, ftretch it to what length they can. Now, M. *Reaumur* fhews, that in the common way of drawing gold-wire, a cylinder of filver 22 inches long, and 15 lines in diameter, is ftretch'd to 1163520 feet; or is 634692 times longer than before; which amounts to about 97 leagues. To wind this thread on filk, for ufe, they firft flatten it; in doing which, it ftretches at leaft $\frac{1}{7}$ further; fo that the 22 inches are now 111 leagues: but in the flattening, inftead of $\frac{1}{7}$, they could ftretch it $\frac{1}{4}$; which would bring it to 120 leagues. This appears a prodigious extenfion; and yet it is nothing.

The cylinder of filver might only have been cover'd with one ounce of gold, inftead of fix which we have hitherto fuppofed: the gilding, indeed, in this latter cafe, will be but thin; but ftill 'twill be gilding, and no point but will have its cover of gold. On this footing, M. *Reaumur* computes, that the thicknefs of the gold-leaf on the wire, is $\frac{1}{5400000}$ of a line. He adds, that as the gold-leaf is not every where of the fame thicknefs, but at leaft twice as thick in fome parts as others; in the thinneft parts it will not be above a 5250000th part of a line, or the 63000000th part of an inch.

Yet is not this the fartheft we can go: In flatting the wire gently between two wheels, it may be extended to double the breadth hitherto fuppofed; in which cafe the thicknefs of the leaf will be reduced to lefs than a millionth part of a line, or a twelve millionth of an inch.

Yet, after all, putting a piece of this gilt wire in *aqua fortis*, the filver will be diffolved, and the gold left a perfect, continuous tube. *Mem. de l'Acad. An.* 1713.

very intenſe heat; it was found at the end of two months not to have loſt any ſenſible part of its weight; tho' it had been all along kept in a continual fluor, inſomuch that all other bodies would have been entirely diſſipated therein in a much leſs time *.

*Cauſe hereof.* Whence this property ſhould ariſe, is not eaſy to ſay; unleſs it be hence, that the particles of gold being all homogeneous, and equal, do equally ſuſtain each other, and leave equal pores between them, through which, when fuſed, the fire finds an eaſy paſſage. The ſame property is obſervable, tho' not in the ſame degree, in ſilver: the other metals are much leſs fixed, as containing too much ſulphur, which volatilizes, and carries them off in fume.

From this circumſtance of fixity, ſome have argued, that gold alone has its juſt proportion of fire; and is itſelf no other than fire perfectly concentrated †.

But M. *Tſchirnhauſen*, and others, have made large double burning-glaſſes, in whoſe *Foci* even gold itſelf readily volatilizes, and evaporates ||: particularly, in the year 1709, a quantity of gold was thereby converted into glaſs **; being firſt fuſed into a ſort of calx, which emitted fumes, and loſt of its weight: tho' the ſame calx, fuſed again with a portion of fat, was reſtored to gold. And the like experiments have been made at *London* with M. *Villette*'s burning concave.

Hence

* It may be obſerved, however, that gold, mix'd with other volatile bodies, does evaporate; but this is the effect of the great volatility of thoſe bodies, which can carry off the gold along with them. "If we conſider," ſays Mr. *Boyle*, "how "very minute the parts are whereof gold "conſiſts, and into which it is diviſible, it "will not ſeem impoſſible, that if we "could light of volatile ſalts of figures "fit to ſtick faſt to the corpuſcles of gold, "they would carry them up along with "them. Accordingly, we have made "more than one menſtruum, with which "ſome particles of gold may be carried "up: but upon applying the *menſtruum* "*peracutum*, which conſiſts of ſpirit of "nitre drawn from butter of antimony, I "was able, without a very violent fire, "and in the ſpace of a few hours, to "raiſe ſo much crude gold as afforded a "conſiderable quantity of ſublimate." *Mech. Orig. of Volatil. &c.*

† M. *Homberg*, and others, we have already obſerved, make gold conſiſt of mercury, and ſulphur; and the ſulphur, to be nothing but the matter of light, or fire. See the note *p.* 16. As alſo the chapter, *Of Fire.*

|| Gold expoſed, in a cuppel, to a large burning-glaſs, crackles, emits fumes, gradually diminiſhes, and leaves a ruddy dye around the veſſel: 'tis, probably, no other than the earth of the metal that gives that redneſs; for there is no recovering of any thing like gold from it: ſo that one would imagine it ſomething accruing from a ſort of analyſis of the gold.

** Some philoſophers, however, conteſt the reality of this vitrification: 'tis certain, that if gold be expoſed to the focus of a burning-glaſs on a piece of charcoal, as is uſually done, it ſenſibly diminiſhes; and in proportion to the diminution, there ariſe an infinite number of little glaſſy drops of a greeniſh colour, which ſwell, and enlarge, in proportion as the gold diſappears. "But this," ſay ſome, "is no demonſtra-"tion that the gold is vitrified: 'tis ra-"ther the aſhes of the coal, which, amal-"gamating with the gold, afterwards vitri-"fies: for let gold evaporate on a body "which yields no aſhes, and you have "no glaſs. Add, that if this glaſs be fuſed "over

Hence, we conclude, that there is no body abſolutely *fix'd*, in all nature; ſince gold, which has the faireſt pretenſions, is not ſo.

The fourth *character* of gold, is that it requires a vehement fire, to fuſe it; greater, conſiderably, than either lead, or tin; tho' a much leſs than iron, or copper ††. *Fuſibility.*

Add, that whereas ſome metals, as tin for example, diſſolve e'er they ignite; gold ignites, or grows red-hot, e'er it diſſolves: which difference ariſes hence, that the one ſuſtains a greater degree of heat, e'er it fuſes, than the other.

Its *fifth character* is, not to be diſſolvable by any menſtruum in nature, except *Aqua regia*, and mercury. *In what menſtruums diſſoluble.*

*Aqua regia* takes its denomination from this property of diſſolving gold, which among the chemiſts is called *Rex*, the king; its baſis, or eſſential ingredient, is common, or ſea-ſalt, which anſwers the purpoſe in whatever form applied; whether as a fluid, or a ſolid; a liquor, or a ſpirit. Aqua Regia.

Sal-gem, and ſal-armoniac, do either of them occaſionally anſwer the ſame end, as ſea-ſalt; but 'tis only ſo far as they are of the ſame nature and kind with ſea-ſalt; as will be ſhewn in the chapter, *Of Salts*.

*Aqua regia*, then, is a ſort of *Aqua fortis*, or acid ſpirit, wherein there is a ſmall proportion of ſea-ſalt: 'tis prepared four ſeveral ways:

1°, By mixing common ſalt, ſal-gem, or ſal-armoniac, whether native or factitious, with *Aqua fortis*, or ſpirit of nitre. *Preparation of* Aqua Regia.

2°, Of butter of antimony, with which Mr. *Boyle* made a menſtruum that diſſolved gold with ſurprizing readineſs; but this does not infer, that gold may be diſſolved without ſea-ſalt; for butter of antimony is made partly of mercury ſublimate, wherein ſea-ſalt is one ingredient *.

3°, *Aqua regia* may be made of ſea-ſalt reduced into a *ſpirit*, by diſtillation; for ſuch ſpirit of ſalt is known to diſſolve gold.

4°, Of human urine; for this being diſtill'd by a vehement fire to make *phoſphorus*, there remains at the bottom of the veſſel a ſort of a ſalt perfectly like ſea-ſalt; which, mixed with ſpirit of nitre, makes a menſtruum that diſſolves gold.

To conclude, no ſpirit, or ſalt, whether acid, or alcalious, affects gold, unleſs it have a mixture of common, or ſea-ſalt: thus, if you take a dram of gold, put it into a clean glaſs-veſſel, and pour upon it ſpirit of ſulphur *per campanam*, oil of vitriol, or ſpirit of nitre, either hot or cold; it will

" over again, and a fatty matter added " thereto, it does not return to its for- " mer ſtate of gold, as all other metals are " found to do. *Nouv. Cours de Chymie, p.* 272.

†† M. *Flacourt*, indeed, in his hiſtory of the iſland of *Madagaſcar*, mentions a kind of gold found there, called by the natives, *Malacaſſean* gold; which melts almoſt as eaſily as lead: while the fine gold we deal with, requires vehement fires, with borax to facilitate its fuſion. *Boyle Uſeful. of Exper. Philoſ.*

* *Jo. Agricola* tells us, what ſeems very ſtrange, that the ſpirit of *Terra Sileſiaca* diſſolves gold, as well as *Aqua Regia*, tho' more ſlowly, into a red ſolution, which in a few days precipitates the gold in fine powder. *Boyle Uſeful of Exper. Philoſ.*

have no effect on the gold; or if *Aqua fortis* be distil'd from nitre and vitriol, the gold will remain as untouch'd as if it were a diamond: but if into so many vials, each containing one of these saline liquors, with a quantity of gold, you pour a little sea-salt, or sal-gem, either in form of a spirit, or of a lixivium; the gold will be instantly dissolved; and soonest in the vial that contains spirit of nitre. 'Twas a notable saying, therefore, of the antient chemists, that the *sun and salt contain all things*. The truth is, sea-salt is a thing of so very beneficial a nature, that we had better be without gold, than this salt.

*Gold attracts and absorbs mercury.*

The *sixth character* of gold is, that it readily, and spontaneously, as if by some magnetic power, attracts, and absorbs mercury.

Tho', what my Lord *Bacon* writes, *viz.* that gold imbibing mercury, increases in weight, we doubt is not well warranted. See his *Nat. Hist. pag.* 124. *Edit. Francofurt.* In effect, we have made the experiment with contrary success; having always found the gold dilated, or increased by the mercury in bulk more than weight; and consequently its specific gravity diminished. Thus, if a grain of mercury be mixed with two grains of gold of 20 carats fine, and the mass be weigh'd hydrostatically against two grains of the same gold, void of mercury; it will be found specifically lighter: Add, that as soon as the mercury enters the gold, it is render'd soft, and like a paste; and of consequence is thinn'd or diluted. Upon the whole 'tis probable, that the noble *Bacon* had not himself made the experiment, but took the relation from others.

*Its specific gravity diminished thereby.*

The *seventh character* of gold is, that it resists the force both of lead, and antimony: by *resisting*, we mean, that when melted with them in the cupel, it does not dissipate, and fly off with them in fume; but remains fixed.

The chemists have two kinds of lead, or *Saturn: viz.* the *Saturn of* Diana, or common lead; and that of *Sol*, called also the *Saturn of the philosophers*, which is antimony. None but gold and silver resist the first; and none but gold alone the second; each they term *Lavacrum Leprosorum*, or the *Lepers Bath*; from which they arise the cleaner: intimating hereby, that all other metals by them deem'd leprous, ☉ and ☾ excepted, fused in the same cupel with lead, or antimony, fly off in fume.

Lead, particularly, they call *Balneum Solis & Lunæ*, *The Sun and Moon's Bath*; or, *Balneum Regis & Reginæ*; as silver and gold thence come out the purer, and all other metals perish therein.

*Sustains the force of lead.*

Thus, if a mass, consisting of gold, silver, copper, and other metals, together with stones, and other bodies, be fused with ten times the quantity of lead; the stones, and all the other bodies beside metals, will swim on the surface, and be easily blown off by the bellows. In the mean time, the lead drawing all the metals, except the gold and silver, to itself, rises along with them into a sort of froth; and is likewise blown off by the bellows, or goes away in fume, or vitrifies with the cupel.

As

As to antimony, a quantity thereof being put in a cupel, along with pure gold, and the whole fused, and kept in a ſtrong fire; the antimony all evaporates, and leaves the gold alone: which does not hold of any other metal, not even *ſilver* itſelf. Whence antimony is particularly called *Balneum Solis*, the ſun's bath; and *Lavamen ſolius Regis*; *Devorator*; and *Lupus Metallorum*, &c. *And of antimony.*

*Centivoglio* introduces antimony, ſaying, by way of proſopopœia, "I have "a bath wherein every thing that enters is loſt, except the king, who "waſhes therein with ſecurity, and comes out the fairer, only he loſes his "cloak:" where, by *cloak*, is meant the pellicle uſually found on the ſurface of the gold; or elſe the heterogeneous matters mix'd with it. For a maſs of metals, ſtones, and earth, being fuſed with antimony, all but the metallic part will be thrown off together with the impurities of the metal.

Hence, antimony is uſed as the laſt teſt of gold; to try the purity whereof, one or two grains is melted in a cupel with twenty-times the quantity of *regulus* of antimony, till ſuch time as the antimony is either evaporated, or turn'd to a ſcoria, to be blown away by the bellows, and the gold have *fulminated*, as the refiners affect to call it; that is, till its ſurface appear every where ſimilar, and equable. This done, if the gold have loſt nothing of its weight, it is allowed perfectly pure, and called *gold of twenty-four carats*; or if it be found $\frac{1}{24}$ lighter, it is ſaid to be twenty-three carats fine.

The *eighth character* is, that its ſound, when pure, is not very clear, or tinkling, but rather obtuſe, and reſembling that of lead. *Its ſound.*

For gold being ſoft and flexible, has but little elaſticity, and conſequently is not much diſpoſed to the trembling or vibratory motion neceſſary to produce ſound. Add ſilver or copper to it, and it becomes ſonorous enough: but without any admixture, the chemiſts even hold, that it yields no ſound at all.

Hence, the chemiſts hold, that whoever would convert another metal into gold, muſt firſt take away its ſound.

The *ninth character* is, that, of all known bodies, it is the ſimpleſt; the primary elements being here out of the queſtion. *Simplicity.*

By a *ſimple* body, we mean that whoſe minuteſt part has all the phyſical properties of the whole maſs. Thus, if a grain of gold be diſſolved in *Aqua regia*, and a ſingle drop of the ſolution be taken; a quantity of gold may be ſeparated therefrom, which ſhall only be the millionth part of the grain, and yet have all the characters of gold. Or, if you fuſe a ſingle grain of gold with a maſs of ſilver, and mix the whole together, ſo that the gold is equally diſtributed thro' the whole maſs; you will have in every particle of the lump a particle of perfect gold, in all reſpects like the whole grain. Accordingly, diſſolve any part of the mixture in *Aqua fortis*, and a quantity of gold will precipitate to the bottom; bearing the ſame proportion to the grain, that the part diſſolved did to the whole maſs.

*Art of essaying.* And on this principle chiefly depends the art of essaying: for if you carry a mass of gilt silver to an artist, he takes a single grain thereof, melts it at the fire, to see whether the gold and silver are well mix'd; then casts it into *Aqua fortis* to have the silver dissolved, and the gold left alone. And from the proportion of the gold to the whole grain, he computes how much gold is in the whole mass.

This exceeding simplicity of gold induced the antient chemists to believe, that it was more difficult to destroy, than to make gold: for, by destroying, they meant the changing it into some other substance *.

The alchemists, however, hold their *Aurum Philosophorum* to be still more simple than our gold; as consisting of mercury perfectly cleared from all sulphur; but whether there be any such thing in nature, will admit of a question: mercury, absolutely pure, and free of sulphur, being what we must acknowledge ourselves never to have seen.

These are all the sensible criterions of gold; so that it is next to impossible to be deceived therein: for wherever these nine properties concur, there is certainly gold; and where they are all wanting, there is none.

Take, for instance, a single grain of metal pretended to be gold, and which has many appearances of it; put it along with three grains of antimony, in a cupel, and fuse it for the space of an hour: if the gold be pure, the whole grain will be found at the bottom; otherwise, the foreign, or adulterate part, will be all gone off, with the antimony: which is a proof there is no possibility of eluding, nor any danger of being deceiv'd by. Such characteristics of metals, and chiefly gold, are of frequent use in life; and especially to persons who have to do with that subtile tribe, the alchemists.

* Mr. *Boyle*, indeed, gives us an experiment, wherein a quantity of pure gold was so changed, and debased by the admixture of an exceeding little quantity of a certain powder cast into it, in fusion; that, beside detaching a large metalline recrement, not unlike bell-metal, the gold itself was left of a dirty colour, and withal had lost of its specific gravity; so that, instead of 19 times the weight of water which it had at first, it was now only $15\frac{2}{3}$. This operation appears to Mr. *Boyle* almost as strange as projection. *Boyle Useful. of Exper. Philos.*

The

## *The Form wherein Gold is found.*

GOLD is found in three different manners, or forms. *Gold found pure.*

1°, In pure *glebes*, or clods, consisting of gold alone; in which form it is said to be sometimes met withal in *Hungary*: accordingly, in the *emperor's* collection are preserved several plates of pure gold, so found in the mines *.

2°, It is found in form of a pure dust, call'd αμμοχρυσος, gold-dust, or sand-gold, in the sands and mud of some rivers, brooks, &c. particularly in *Guinea*; being wash'd down from the mountains, or torn from hidden veins by the violence of waters, and gather'd up by the miserable natives †. *Gold-dust.*

3°, It is also found, and that most usually, in whitish clods, dug out of mines || 150, or 160 fathoms deep, intermixed with other fossils, as antimony, vitriol, sulphur, earths, stones, and other metals; particularly silver, which is scarce ever found without a share of gold **. *Intermixed with other minerals.*

In effect, 'tis very rare that gold is found pure, or otherwise than under this last form: we have specimens in our keeping from most parts of the habitable globe; but none of them pure, except those from the coasts of *Guinea*: tho' the greatest part brought from thence contains some impure heterogeneous parts; the *Negroes* being apt clandestinely to mix filings of brass or copper therewith.

* The mountains of *Chily*, also, afford gold in this form: in the clefts, or drains, between the ridges, is found a fine, ruddy earth, beneath which is a lay of blue stony matter, streak'd here and there with yellow; and under this are grains of pure gold, frequently of considerable size.

To procure the gold, they direct the current of some rivulet hither, to help carry off the incumbent earth, and lay the bed of gold bare. This done, they dig up the precious earth, and carry it to the *Lavaderos*; where, by repeated lotion, the earthy lighter part is separated, and the gold left alone. *Dict. de Com.*

† "There is also a place in *Scotland*, "where, over a lead mine, near the surface of the ground, they often find large "grains of native gold, free from any "spar.——I have still a piece of native metal by me, which came from the same "place, in weight above forty grains, "wherein gold is the predominant metal." *Boyle Hydrost. Bal.*

|| "They have work'd in the gold-mine "at *Cremnitz*," says Dr. *Brown*, "now upwards of 900 years. The mine is several "*English* miles in length, and about 160 "fathoms deep.——Of the ore, some is "white, some black, red, and yellow.— "It is not rich enough to admit any proof "in a small parcel, to find the proportion "of metal it contains; but they pound a "very large quantity of it, and wash it "in a little river running nigh the place. "The whole river being divided into several cuts, runs over the ore continually, and so washes away the earthy "parts from the metalline.—The common "yellow earth of the country all about, "tho' not esteemed ore, affords some gold: "And in one place, I saw the side of a "hill dug away, which had been cast into "the works, wash'd, and wrought in the "same manner as pounded ore, with considerable profit." *Phil. Transact.* N° 58.

** It may be added, that gold is sometimes, also, obtain'd from copper-ore; from tin-ore, from common marcassite, from a red earth, from sand, from *German* talc, &c. See *Boyle Useful. of Exper. Philos.* and *Hydrostat. Bal.*

*Laz. Ercker*, arch-miner, and eſſay-maſter to three emperors of *Germany*, under whoſe direction were all the mines of *Germany*, *Hungary*, *Tranſylvania*, *Bohemia*, aſſures us, "That 'tis rare any earth produces pure gold; "but one metal or other ſtill grows with it: and even where it appears "pureſt of all, it has its ſhare of ſilver." He adds, as an univerſal rule, that where gold appears the pureſt, there is ſilver mix'd along with it; and where it is the hardeſt, there is both braſs and ſilver.

## *Method of ſeparating Gold.*

*Gold how procured from the matters it is found among.* WE have obſerved, that the gold dug out of mines has always ſome foreign matter adhering to it; particularly ſulphur, earths, and other metals: whence ariſe ſeveral proceſſes or operations, for the ſepating, or clearing it of the ſame.

*By torrifaction and calcination.* The firſt is, to reverberate the maſs in the fire; that is, to lay it on a grate, or grid-iron, and there torrify or roaſt it, ſtirring, and turning it continually, till all the ſulphur be evaporated, and gone off in ſmoke. This is perform'd in the mines, by the workmen themſelves; and is call'd *torrifying*, *fuming*, and *ſeparating* gold from the ſulphur.

*Coction.* 2°, After torrifying, and gently bruiſing the maſs, they boil it in water, till it has loſt both its taſte, and ſmell; pouring on, from time to time, freſh water, and throwing away the old. At length, after a ſufficient coction, the water is pour'd out, and the gold reſts at bottom. The maſs at the bottom of the veſſel being well dried, they try in the cupel whether it be gold or not.

*Amalgamation.* 3°, If it be not, they grind the maſs into powder, and boil it up with mercury and ſalt, for five or ſix days; and after 'tis ground, boil'd, and elixated, what remains, is well dried, and ſtoutly pounded with mercury in a large mortar. Upon this, the mercury, by its attraction and agreement with gold, draws to itſelf all the gold, and even the reſt of the metallic part; it having a peculiar property of uniting to itſelf, immediately, either gold, ſilver, copper, or lead; tin more ſlowly; iron or ſtone never. It alſo joins itſelf to oil and ſulphur: but in this caſe, the ſulphur is ſuppoſed all taken away by the firſt proceſs; and all the ſalt and oil elixated by the ſecond. If theſe were remaining, the whole would make a ſort of cinnabar; but as they are away, the only impurities remaining, beſide ſilver, copper, and lead, are iron, and ſtones.

*Lotion.* 4°, Things brought to this paſs, the whole maſs, mercury and all, is put in a large urn, or trough, and water pour'd upon it; and the whole ſtirr'd briſkly about: out of this veſſel the water is poured into another, where it is ſtirr'd as before; and out of that poured into a third: by which means, the earthy part is kept ſuſpended in the water, and the heavy metallic part ſubſides. This operation they continue ſo long, and repeat ſo often, till the water is found perfectly clear.

5°, What

5°, What remains at the bottom, they put in a crucible, or iron veſſel, ſet it on the naked fire; and, after an intenſe heat, find all the metallic matter at the bottom, and the *ſcoria* at the top.

6°, The maſs of metal at the bottom, they ſeparate from the mercury, by adding lead thereto, and diſtilling the whole in a cupel; upon which, the mercury, *&c.* flies off, leaving only the gold and ſilver at the bottom: then they pour thereon either *Aqua Regia*, or *Aqua fortis*; the firſt diſſolving the gold, and leaving the ſilver entire; and the latter diſſolving the ſilver, and leaving the gold entire. And by ſuch means they are ſeparated from each other *. *Diſtillation.* *Diſſolution.*

This is much the fineſt, and moſt artful way of getting gold out of the ore; tho' tis but of modern invention: had the *Spaniards* been acquainted with it, from their firſt ſettlement in *America*, they had ſaved immenſely thereby.

Gold, 'tis commonly ſuppoſed, does not contract ruſt; but miſtakenly: for being placed in the fumes of ſea-ſalt, its ſurface is grated, and diſſolved thereby, and becomes ruſty; the ruſt of a metal being nothing elſe but the exterior part thereof converted, by ſome corroſive ſalt, into a ſort of calx, adhering to the body, in form of metalline flowers †. *Gold liable to ruſt.*

*MER-*

* The method here deſcribed, is that practiſed by the *Spaniards*, in *Peru*; but, as the quality of the ore is various, in various places, different proceſſes are to be had recourſe to. That uſed at *Schemnitz*, *&c.* in *Hungary*, is given us by Dr. *Brown*, as follows:

" They have divers ways of taking the " gold out of its ore; by burning the " ore, by melting it, by adding ſilver-ore, " and other minerals, ſand, and lead, as " they find the ore fluid, or fix'd. With- " out lead, the proceſs is thus:

" They break, and pound the ore very " fine, in water; and then waſh it often, " and lay it in powder upon cloths, and " by the gentle, oblique deſcent of the " water over it, and their continual ſtir- " ring it, the earthy, clayey, and lighter " parts are waſh'd away, the heavier and " metalline remaining in the cloths. " Theſe cloths they afterwards waſh " clean in ſeveral tubs; and, after ſome " ſettling, pour off the water from the " ſediment, waſhing the ſediment over " again, and ſtirring it up, in ſeveral veſ- " ſels. At length, they ſprinkle quick- " ſilver on it, and knead it well together " for an hour; then waſhing it again in a " wooden veſſel, after ſeparating ſo much " of it as the quick-ſilver does not touch, " by ſtriking the veſſel againſt their leg, " they bring the gold and quick-ſilver to- " gether, in an amalgama, to a corner. " From this amalgama they ſtrain as much " of the quick-ſilver as they can; firſt, " thro coarſe cloths, and then thro finer: " then put the remaining maſs on a per- " forated plate, which they ſet over a " deep pan placed in the earth; in the " bottom whereof, they alſo put quick- " ſilver. This pan they cover, and lute " the cover well; then make a charcoal " fire on it, and drive the quick-ſilver yet " remaining in the gold to the reſt in the " bottom of the pan. Laſtly, taking out " the gold, they caſt it into the fire, to " render it purer." *Philoſ. Tranſact.* N° 58.

† The antient phyſicians ſay nothing of any medicinal virtue in gold: The firſt who mention it are the *Arabs*; *Avicenna* gives it mighty eloges; but it appears, he ſpeaks rather from conjecture than experience. The alchemiſts, however, have carried the thought much further: they will have this metal contain I know not what radical balm of life capable of reſtoring health, and continuing it to the longeſt period. Gold, ſay they, has in it a ſulphur perfectly friendly to nature, like that

## *MERCURY*, or, *Quick-Silver.*

*Mercury.*
*Its weight.*

THe *first character* or *property* of mercury, is, that it is the heaviest of all bodies except gold. From the table it appears, that there is no body of intermediate weight between the two; so that every body which weighs more in *specie* than mercury is gold. And still the purer mercury is, the heavier it is found; insomuch, that some philosophers hold, that mercury perfectly defecate, and purg'd of all its sulphur, would exceed even the weight of gold itself. The ordinary proportion we have observ'd, is that of 14 to 19: if any mercury be found to weigh more than according to this rate, it may be safely concluded to have gold in it.

*Fluidity.*

The *second character* of mercury is to be the most fluid of all bodies, *i. e.* its parts separate, and recede from each other by the smallest force; consequently, of all bodies, it is that whose parts cohere the least, or are the least tenacious; and therefore, of all others the least ductile, and malleable.

that of the sun, which animates the universe: and on such notions have they form'd a thousand chimerical projects, which experiment has always falsify'd.

What led the *Arabs*, and alchemists to imagine such wonderful virtue in gold, was, that they perceiv'd certain qualities therein, which they fancied must be convey'd thereby into the body: gold, for instance, is not capable of being destroy'd; hence they concluded it must be very proper to preserve animal substances, and save them from putrefaction: which is a method of reasoning much like that of some fanciful physicians, who sought for an assuaging remedy in the blood of an ass's ear, by reason the ass is a very calm beast.

Yet, no doubt but gold may have its effect. 'Tis known, that being dissolved in *Aqua regia*, and precipitated by oil of tartar, it is a gentle purgative: and the like has even been observed of gold swallow'd in substance. But there is nothing in these cases but what may arise from its mere gravity. The intestinal glands being briskly struck by the metallic parts, will be put into more frequent contractions; and by these reiterated vibrations, the humour secreted in them will be more plentifully express'd. Further, Mr. *Boyle* observes, that the same solution of gold being calcined with flowers of sulphur, becomes diaphoretic: which suggests how much of the virtue of gold may depend on the matters it is prepared withal.

Add, that the alchemists place all their hopes in the sulphur of gold; whereas, we have a strong presumption, that there is no singular virtue in the sulphur of any metal whatever; since, when that is evaporated, any fatty matter, whether of an animal, or vegetable, will supply its place; and being added to the calx of the metal, will revivify, and give it its pristine form.

Yet does gold still retain some use in medicine. The *Aurum Potabile*, in particular, is prais'd; tho' the attempts to make it, so seldom succeed aright, that many have pronounced the preparation impracticable. Mr. *Boyle*, however, assures us, he had a *menstruum* which with a gentle heat would soon bring gold enough over upon a first or second distillation to afford a high, yellow, volatile tincture: But, as he could easily recover a malleable gold therefrom, he durst not pretend to do any wonders with the tincture. The same author observes, that the solution of gold applied externally, may have very considerable effects; and those of a different kind from what it has internally: of which he gives instances in the piles, and venereal disorders.

The

The parts of water do not divide ſo readily as thoſe of quick-ſilver; and the parts of oil much leſs: there is a certain tenacity even in the parts of ſpirit of wine, which reſiſts a ſeparation; but there is ſcarce any coheſion at all, in the parts of mercury.

If you take, for inſtance, a ſingle grain thereof, lay it on a looking-glaſs in dry weather, and in a place not duſty, and apply a lens thereto which only touches it in one point; the grain of mercury will fly into 1000 globules; each of which, upon the leaſt touch of the lens, will again fly into 1000 leſſer globules, and ſo on, paſt comprehenſion. And yet all theſe globules, tho' infinitely reduced, remain unchanged as to weight, opacity, and ſeparability. *Separability.*

To be eaſily ſeparable, therefore, we lay down as one of the characteriſticks of mercury.

*Centivoglio*, an eminent alchemiſt, introduces *Mercury* addreſſing a philoſopher, thus: "Good alchemiſt, 'tis a faculty given me by nature to deceive and amuſe all the world: for do but view my body; divide it into a thouſand parts; turn it again, and again; and you will find that ſuch as my outſide appears, ſuch my inſide is: do what you liſt with me, you'll get nothing out of me, for I am immutable".

The particles of mercury, view'd with a microſcope, appear perfectly ſmooth and polite; and reflect objects: ſo that looking in 'em, you ſee all the circumjacent bodies, as in a mirror*. *Politure.*

The *third property* of mercury, which indeed depends on the ſecond, is, that of all bodies it is diviſible into the minuteſt parts. *Diviſibility.*

Thus, being expoſed to the fire, it reſolves into a fume ſcarce perceivable to the eye; but in whatever manner it be divided, it ſtill retains its nature, and is the ſame ſpecific fluid: for the vapours of diſtilled, or volatilized mercury receiv'd in water, moiſt leather, or the like, become pure mercury. And if mercury be mix'd with other bodies, in order to fix it, (for it is ſcarce fixable of it ſelf) it is eaſily ſeparable from 'em again, by fire; and reducible into as pure mercury, as before.

The *fourth character* is, to be extremely volatile; being convertible into fumes, even by a ſand-heat. *Volatility.*

In effect, it does not ſuſtain the fire long enough either to boil, or ignite: tho' it muſt be added, that if the fire be at firſt very gentle, and increas'd by eaſy degrees, it may be retained therein a pretty long time; and be fix'd, ſo as at length to ignite in the crucible: As we learn from ſome very tedious experiments made at *Paris*.

The gilders are but too well acquainted with theſe fumes of mercury, which frequently render 'em epileptick, and paralytick, and ſometimes ſa- *Effect of its fumes.*

* Mr. *Boyle* propoſes the applying a microſcope to the minute particles of mercury; by means whereof, a globule, inviſible to the beſt eye, will afford a pleaſant and diſtinct proſpect of all the neighbouring objects. On *forms and qualities.*

L  livate.

livate 'em; being of ſo penetrating a nature, as to take away ſcirrhous tumours; tho' very apt to reach and deſtroy the nobler parts.

*Incorporates with other metals.*

The *fifth property* is, that it eaſily enters, and intimately adheres to gold; leſs eaſily to any of the other metals; with difficulty to copper, and not at all to iron.

*But not with iron.*

Indeed, we have heard much talk among the adepts of making an amalgama, with mercury and iron; but the experiment would never ſucceed with us. 'Tis poſſible there may be ſome way of binding thoſe two bodies together; and, no doubt an amalgama might be made, by adding a large quantity of gold to the iron: but then, if the compound were beaten to a duſt, the iron would waſh away in water, and the gold remain.

On this account it is, that ſuch as have occaſion to handle quickſilver, always make choice of iron inſtruments for that purpoſe.

*Its effect on gold.*

Mercury, in adhering to gold, we obſerve, renders it humid: thus we have known women in a ſalivation have their ear-rings grow white, and ſoft, with the effluvia of the mercury. And hence the gilders, to lay gold on any other body, diſſolve it in hot mercury; which done, they apply the ſolution on the body to be gilt, ſuppoſe ſilver: then ſetting it over the coals, the mercury flies away, and leaves the gold adhering like a cruſt, to the ſilver: laſtly, rubbing the cruſt with lapis hæmatites, the ſilver is gilt.

*Uſe in gilding.*

*Adheres to nothing but metals.*

It may be added, that mercury is a fluid which adheres to no body but metalline ones; unleſs driven thereto by force of attrition, as in æthiops mineral, where by a long, inceſſant rubbing, mercury and ſulphur are made to mix, and ſtick together. And hence mercury is called the "water that wets not the hands".

*Suſceptible of the greateſt degree of heat and cold, of all fluids.*

Its fixth *character* is, that of all fluids it is the coldeſt, and the hotteſt; ſuppoſing the circumſtances alike.

We ſhall ſhew, in its place, that fire is equably diffus'd thro' all bodies; and that there is in reality the ſame degree thereof in mercury, as in ſpirit of wine: and yet if you try with your finger, mercury, in the cold, will appear much colder, and over the ſame fire, conſiderably hotter, than the ſpirit.

*Whence this ariſes.*

This property depends on the great weight of mercury: for the heat and cold of all bodies, is, *cæteris paribus*, as their weights: now, mercury being 14 times heavier than water, if both of 'em be expoſed in a winter's night to the ſame cold; the mercury muſt be ſo much colder than water, as it is heavier.* So, alſo, if they be both applied to the ſame degree of heat; while the water is barely warm, the mercury will be hot enough to burn the hands.

* Notwithſtanding mercury receives ſuch a degree of cold, its great ſeparability, and fluidity prevents its congealing. Mr. *Boyle* tried various ways to bring it to freeze, by making an extream cold, and expoſing an exceedingly thin skin of mercury thereto; but without effect. *Hiſt. of Cold.*

Thus,

Thus, in ſpirit of wine, we perceive a ſlight degree of cold; more in water; and moſt in mercury.

The ſeventh *property* is, that it diſſolves in almoſt all acids, and unites it ſelf with 'em: at leaſt with all mineral acids. *Diſſolves in all acid liquors.*

Thus we find it diſſolve in oil of vitriol, ſpirit of ſulphur *per campanam*, ſpirit of nitre, and *aqua regia.*

It is united with oil of vitriol into *turbith mineral*; with ſpirit of ſulphur into cinnabar; with *aqua regia*, or ſpirit of ſea-ſalt, or ſal-gemma, into corroſive ſublimate. Yet vinegar does not diſſolve it; and hence we are furniſhed with a method of detecting the frauds of druggiſts, &c. who make a practice of ſophiſticating quick-ſilver with lead. For, take and pound the mercury in a mortar, with vinegar therein; and if the vinegar grow ſweetiſh, 'tis a proof the mercury is mix'd with lead: if it have been adulterated with copper, the mercury will turn greeniſh, or blueiſh; but if unadulterate, the mercury and vinegar will both remain without alteration. *Except vinegar.* *To detect the ſophiſtications of mercury.*

The eighth *property* is, that it is the moſt ſimple of all bodies, after gold. *Its ſimplicity.*

Accordingly we find it the ſame in all its parts, ſo far as our obſervation goes: if a ſingle grain thereof be diſſolved in ſpirit of nitre, a proportionable part of the grain will be diſtributed into every minute particle of the ſpirit: and by diluting the whole with an ounce of *Aqua ſtygia*, the whole grain of mercury will be recover'd *.

Had we the *mercury* of the philoſophers, ſo much talk'd of; called alſo *vital mercury, mercury of metals*, &c. 'tis aſſerted we would find it ſtill vaſtly ſimpler even than gold: for, from gold, we can ſometimes ſeparate mercury, and ſometimes ſulphur; but from pure mercury, nothing beſide it ſelf can be ſeparated. Hence *Helmont* holds, that all things in nature de-

* This great ſimplicity of mercury, has made it paſs among chemiſts for one of the ſimple, primary elements of bodies; and even M. *Homberg*, who conſiders an element or principle in a ſtricter ſenſe than many of the reſt, *viz.* as a body which cannot by any analyſis be reduced into ſimpler parts, treats mercury as an element: not but that he thinks it a compound; but becauſe the method of decompounding it has not been yet diſcovered. What puts its compoſition almoſt paſt queſtion, is, that it may be deſtroyed, *viz.* by converting it into a perfect metal, and then expoſing it in a large burning glaſs: whereas an element, or perfectly ſimple body, 'tis univerſally allow'd, muſt be abſolutely incorruptible, unchangeable, &c. See the article *of Operations.*

The ſame author ſhews that the perfect metals are only this mercury, having its particles or globules pierc'd on all ſides, and filled with the matter of fire, or light. See the *Corollaries concerning the nature of metals.*

Mercury, therefore, may be conſider'd in three different ſtates: the firſt in its form of a running mercury; the ſecond when render'd into a metal; the third after the deſtruction of the metal. In the firſt ſtate it conſiſts of little ſolid, ſmooth globules: in the ſecond of thoſe ſame globules perforated on all ſides with fine foramina, by the rays of light, which are lodg'd therein. In the third of the ſame globules perforated on all ſides, but the perforations left vacant, and by the paſſing of ſo much light thro' 'em, during the deſtruction, ſo enlarged as to run into another, and thereby leave the mercury little elſe but mere earth.

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pend thereon; and hence it is called *Aqua immortalis*, *Aqua adeptorum*, *Aqua philosophorum*, &c.

*Void of acrimony.* The ninth *property* of mercury, is to be free of any sharpness, or acrimony.

It shews no acrimony to the taste; nor does it corrode any body: and if a carcass were to be buried in quick-silver, it might there remain for ages without being any way hurt.

The extraordinary effects, however, it produces in the body, have given people a notion of its being acid: but the case is otherwise: when received into the blood, it only acts by its weight, and velocity; by the momentum whereof it tears and destroys the vessels, and thus occasions those great alterations, which lead the chemists into their mistake. In effect, all its medicinal operations are to be accounted for from the properties already enumerated.

## *The form wherein* Mercury *is found.*

THe greatest part of our quicksilver is brought from *Friuli*, a province of *Italy*, where there are abundance of mines, belonging to the emperor *; it is here found under three several forms.

*First*, In ruddy glebes, or mineral clods, call'd *cinnabar*.

*Secondly*, In hard, stony glebes, or substances, of a saffron, and sometimes a blackish colour.

*Thirdly*, It is also found pure: for, upon opening holes in the beds of stones, *&c.* there sometimes gushes forth a vein, or stream of pure mercury, call'd *virgin mercury* **.

This last sort is the most valued. *Paracelsus* and *Basil Valentine* prefer it to any other sort for chemical operations: it is supposed to have some acid adhering externally to it, and that if this could be separated, it would become

* Mercury is either found in its own proper mines, or in those of other metals, wherewith it is intermix'd: beside the mines of *Friuli*, there are considerable ones in *Hungary*, and *Spain*. The earth, or matter it is found in, is different in the different places: In the *Spanish* mines, 'tis ruddy, streak'd with black, and so hard, that there is no digging it without gun-powder: that of the *Hungarian* mines, is sometimes, a pretty hard stone, but more usually a dark-colour'd earth, inclining to red: in the mines of *Friuli* there is a softish earth, wherein virgin mercury is found, in little drops; and a hard stone that yields the common mercury.

** Mineralists usually distinguish another sort of *virgin* mercury; for the denomination, it is to be observ'd, is common to all mercury procured without fire. This latter is what is separated from the earth by washing with water, and passing thro' several sieves.

Mercury is also procured from certain vegetables: *S. M. Septali* gives us an account of a plant like the doronicum, and call'd by that name, growing in the valley between the mountains of *Turin*, near whose roots pure mercury is always found, running in small grains. He adds, that if the juice of the plant be express'd, and expos'd to the air in a clear night, there will be found as much mercury, as there is loss of juice. *Philos. Transact.* N°. 27.

come tranſparent, and prove the mercury of the philoſophers. Dr. *Wal. Pope* aſſures us in his travels, that enquiring of one of the directors of the quick-ſilver mines, wherein the difference between this, and common mercury conſiſted, he was anſwer'd, that virgin mercury, mix'd and amalgamated with gold, render'd the gold volatile; and carry'd it all away with it in fume: but this we have ſeveral times tried without ſucceſs.

## *Manner of ſeparating* Mercury.

FIrſt, They grind the mineral glebe into powder: which done, they pour a great quantity of water upon it, ſtirring and working the whole briskly about, till the water become exceeding thick, and turbid: this water having ſtood to ſettle, they pour it off, and ſupply its place with freſh; which they ſtir and work as before. This they repeat, and continue to do till the water, at length, comes away perfectly clear. Then, all remaining at the bottom of the veſſel is mercury, and other metalline matter.

*Mercury procured from the matters it is mixed with.*

*By lotion.*

To this maſs, they add the ſcoria of iron; then, putting the whole in large iron retorts, diſtil it; by which means, all the heterogeneous metallick and ſtony part is ſeparated therefrom, and the mercury brought over pure.

*Diſtillation.*

The virgin mercury ordinarily needs nothing to purify it, but a lotion in common water: tho', ſometimes, it is ſo full of an arſenical matter, that they are oblig'd to ſtrain it thro' a skin; and ſometimes there is an earth united with it ſo ſtrongly, that they are oblig'd to have recourſe to diſtillation.

*Virgin mercury how purified.*

As to the mercury in pure cinnabar, they don't find it worth while to diſtil and get it out; ſuch cinnabar ſelling for a better price than mercury it ſelf.

*The mercury in cinnabar.*

The miſerable people condemned or hired to work in theſe mines, all die in a little time: they are firſt affected with tremors, and proceed to ſalivate; then their teeth drop out, pains ſeize 'em all over, eſpecially in their bones, which the mercury penetrates, and thus die: one of them, after he had been there 6 years, was ſo full of mercury, that holding a piece of gold in his mouth a little while, it became of a ſilver colour; and when taken out, was found heavier than before.

*Mercury works.*

## *LEAD.*

*Lead.*

*Its weight.*

THE *first character* of lead, is to be the heavieſt of all bodies, after mercury. Hence lead, fuſed by fire, conſtitutes a fluid of the third order in point of gravity; wherein all bodies, whether metalline or not, excepting gold and mercury, are ſuſpended.

If all the *fæces* of lead could be perfectly purged away, its weight, *&c.* would approach nearly to that of mercury. Accordingly, in analyzing this metal, we always find it yields a conſiderable quantity of mercury; tho' what the other ingredient is, united with the mercurial part, is hard to ſay.

*Affinity with gold.*

Lead, tho' the leaſt valued among metals, has yet the greateſt affinity of any with gold; at leaſt in point of weight, which *Helmont*, and others, allow to be the moſt diſtinguiſhing, and immutable character of gold: and what makes the reſemblance ſtill cloſer, is, that lead does not mix with any metals, except mercurial ones.

*Softneſs.*

The *ſecond character* is, that of all metals, it is the ſofteſt; for there is none, whoſe figure is ſo eaſily changed as that of lead: and hence, alſo, it becomes very ductile, and eaſily flexible; tho' not capable of being drawn out into ſuch ſimple, fine, and yet coherent parts as gold.

*Fuſibility.*

The *third character* is, that of all metals, it melts the readieſt; the fire required to fuſe lead, being not much greater than what is neceſſary to boil water.

In effect, it diſſolves ſo readily, that it is not capable of ignition; and as ſoon as it once begins to run, the whole is in a fluor; and as ſoon as it begins to cool, it ſtrait coagulates: which are circumſtances peculiar to this metal.

*Penetrative nature.*

Hence, as it is the heavieſt of all bodies that are fuſible by the ſame degree of fire, and, of conſequence, the hotteſt; being mixed with other metals, it facilitates their fuſion. Add, that after it has continued a good while in the veſſel, in its fluid ſtate; no veſſel, or inſtrument, is capable of containing it any longer; but it paſſes through them as through a ſpunge: and this even in a metalline veſſel; which it eaſily ouzes thro, and at length carries away the bottom with it.

*The phænomena it affords by force of fire.*

A ſmall quantity of lead being ſet over the fire, no ſooner begins to run, than its ſurface appears exceedingly bright, and ſhines like mercury; but its face ſoon alters, and you diſcern a *nubecula*, or cloud therein, which gradually increaſes, till the whole ſurface appears cloudy, and darken'd with *ſcoria* ſwimming therein in form of a duſt: this duſt being blown away with bellows, there ſtrait ariſes a new ſupply; and ſo on, till the whole lead becomes thus converted into *ſcoria*; excepting a ſmall quantity of impure mercury, which remains at bottom, and which, by further fire, is capable of being brought to a greater purity.

These

These *ſcoriæ* are only the matter of the lead gently calcined; a more violent fire vitrifies them, that is, converts them into a heavy, brittle, pellucid, elaſtic, ſonorous matter, called *glaſs*; into which all metals are indeed convertible, but lead the eaſieſt; and which is of ſuch a penetrative nature, that it flies, without oppoſition, thro' all veſſels, whether of metal, ſtone, earth, wood, or the like. *Its ſcoria.* *Glaſs.*

The calx of lead, we obſerve, has nothing of the appearance of lead; and yet, by only expoſing it to a vehement fire, and adding to it a little iron, the lead is again ſeparated from the maſs; the reſt going off in fume *. *Calx.*

Add, that if while the lead is in fuſion, it be kept continually ſtirring with a ſpatula, it turns into a duſt of a ſcarlet colour, called *minium*, or *red lead:* in which operation, this is further obſervable, that the lead becomes augmented in weight, by the particles of the fire retained and fixed therein. *Minium.*

The *fourth character* is, that it eaſily, and inſtantly diſſolves in almoſt all weak acids; but very difficultly in ſtronger, unleſs they be diluted with water. *Diſſoluble in weak acids.*

Thus, in ſtrong *Aqua fortis*, it diſſolves very ſlowly; and in *Aqua regia* never: but very readily in vinegar, ſmall *Aqua fortis*, *Rheniſh* wine, ſpirit of vinegar, *&c.* and even in ſpirit of nitre, oil of vitriol, and *Aqua regia*, if thoſe *menſtruums* be well diluted, and their acidity weaken'd with water. Add, that in whatever acid it is diſſolved, the ſolution becomes extremely ſweet, like ſugar, or honey itſelf. *Its ſolution ſweet.*

The fumes of wine or vinegar diſſolve it into a white powder, or calx, called *ceruſs*, or *white lead.* *Ceruſs.*

The *fifth character* is, that it diſſipates all metals melted with it, in the cupel, except gold and ſilver; which is a property, that had we been unacquainted with, all our treaſures of gold and ſilver had lain in little compaſs: this being of principal uſe in the obtaining thoſe metals. *Diſſipates metals melted with it.*

The foundation of the proceſs is this: "That any maſs, of what kind "ſoever, whether metal or ſtone, ſalt or ſulphur; gold and ſilver only ex-"cepted; being mixed with lead, and expoſed to the fire, flies away in fume."

Thus, if you take a ſingle grain of gold, four grains of ſilver, eight of iron, and as many of lead; mix them together, with the addition of oils, ſalts, or ſulphurs, at pleaſure: put the whole on the cupel, and expoſe it to the fire of a wind-furnace; it will be found to diſſolve, volatilize, and periſh, or fly off, all to the ſmalleſt grain, excepting the gold and ſilver. *Its uſe in ſeparating gold and ſilver from other matters.*

* Mr. *Boyle* contending, that the calx of a metal is only a magiſtery thereof; and that the principles are not ſeparated, but the bulk of the body preſerved, tho' under a new form; aſſures us he has ſeveral times, from the calx of lead, reduced actual lead itſelf; particularly, that having once taken ſome calx of lead produced by the flame of ſpirit of wine; he found, that without any flux-powder, or other addition, by the mere application of the flame of highly rectified ſpirit of wine, there would, in a ſhort time, be obtained a conſiderable proportion of malleable lead. *Ponderab. of Fire and Flame.*

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The particulars of the procefs we have already defcribed, in the article, *Of Gold*; but there are many things worthy of notice in the trying, and refining metals by lead, which have not yet been mentioned. And,

*Metals fufed together don't range themfelves according to their fpecific gravities.*

1°, It is a circumftance peculiar to metals, that, when fufed together, the lighter don't fwim on the furface of the heavier, but mix, and incorporate therewith. Thus, lead, for all its fuperior gravity, does not raife up filver, copper, &c. towards its furface; but draws *, and imbibes them intimately within its own fubftance, and fo forms them all into one mafs; as falt, diffolved in water, makes one fluid mafs therewith. But, if any thing not metalline be added, it fwims thereon, as wood in water. And by this means, earthy, ftony, and other bodies, are readily feparated together with the *fcoria*, or *calx* of the lead; and the metalline parts left behind with the lead.

From lead or *Saturn*'s thus abforbing the other metals, the antient chemifts call'd it the *devourer of his fons*, &c.

*Glafs of lead not reducible into lead again.*

2°, The lead which, in the operation juft deliver'd, efcapes thro' the pores of the cupel, paffes, as already noted, in form of a *glafs*, which is not capable of being reftored, by any known means, into lead again: whoever could find a way of doing this, would reap immenfe riches from it; there being abundance of minerals which have gold and filver in them, tho' in fuch fmall proportion, as not to compenfate for the great quantity of lead confumed in making the feparation. *Glauber* and *Becher* have attempted this reftauration of lead in various manners, but without fuccefs.

*Litharge.*

3°, If lead be fufed with pure gold, the calx or fpume which it rifes into, and which is ufually blown away with bellows, is called *litharge*; which, if it be but flightly tinged, fo as only to appear of a pale colour, it called *litharge of filver*: but if it be further coloured, fo as to grow yellow, it is term'd *litharge of gold*. And if this litharge be not blown off the teft; but remaining there, be further urged by fire, it penetrates, as already obferved, thro' the pores of the cupel, and efcapes in the form of glafs. So that it is to be allowed no inconfiderable property of lead, that under fuch circumftances it is incapable of being confined in any veffel or prifon whatever; which, no doubt, was what occafion'd the antient chemifts to denominate it *Tortor Gehennæ*. A veffel wherein this vitrified lead would be contained, is another of the *Defiderata* in chemiftry; the difcovery whereof would be an ample fortune.

*Defideratum.*

We fhall add, that if any alchemift can make a matter, which being cupel'd with twenty-times its quantity of lead, can be retained till the mafs fhines, he will have real gold or filver. And to detect the vanity of any one's pretenfions to the fecret of making gold or filver; you need only take a grain of his matter, melt it with two drams of lead; and if it re-

* Sulphur readily joins with lead, and renders it friable; arfenic, in particular, volatilizes it; and it admits of a mixture with tin: but iron it does not mix withal, unlefs that metal be firft reduced to a calx. M. *Sthall* takes one of the main reafons hereof to be the lightnefs of iron. *Nouv. Cours de Chymie.*

main

main behind in the teſt, 'tis gold or ſilver; otherwiſe not. So incorrupt, and infallible a judge is *Saturn:* whom we accordingly find called the *bath of the king and queen*, or of the *ſun and moon*; wherein being immerſed, they lay aſide their garments, and ariſe the purer; while every thing elſe is drowned.

*Centivoglio* having introduced an alchemiſt ſeeking the philoſopher's ſtone, and ſuppoſing him fallen aſleep, *Mercury* addreſſes him thus: "What "would'ſt thou make of me? Gold; replies the alchemiſt. That might "be, ſays *Mercury*; but that here's a lame old fellow, [*Saturn*] who "will make a bath of his own urine, wherein he no ſooner waſhes me "than I ſhall fly away again, and be loſt in air."

*Centivoglio* goes on, "that his alchemiſt was in a garden wherein grew "all kinds of apples; but ſix trees of fairer fruit than the reſt; and that "*Saturn* taſted of them all, but there were only two that he fancied; and "theſe two, after waſhing them in his urine, he proclaimed the faireſt of "all bodies." The meaning of theſe allegories is obvious enough.

Upon the whole, there are three ways, whereby all the matters mixed with gold and ſilver are deſtroy'd, and loſt, when cupel'd with lead: 1°, By volatilizing, and evaporating. 2°, By degenerating into *ſcoria*, and retiring to the ſides of the teſt in form of duſt. 3°, By penetrating the pores of the cupel; which only happens to ſuch bodies as can neither fly off in fumes, nor work to the ſides in the way of *ſcoria*. *Heterogeneous matters mix'd with gold and ſilver, carried off by lead divers ways.*

The *fixth character* of lead, is, that of all metals it is the leaſt ſonorous, and elaſtic; and that it diminiſhes the ſound of other metals, when mixed therewith. *Lead the leaſt ſonorous of all metals.*

This property follows from its ſoftneſs: for if two equal leaden balls be ſtruck with equal velocities againſt each other, they will both remain fix'd in the point of contact, without any vibration, or reſilition at all: ſo that of courſe no ſound can be produced. 'Tis on account of this unelaſticity of lead, that it has been uſed by Dr. *Wallis*, M. *Huygens*, and others, for determining the laws of percuſſion.

By this property lead ſhould appear to be nearly allied to gold, which is the leaſt ſonorous, and ſpringy of all metals, except lead. Accordingly, ſeveral experiments have been produced, to prove that lead melted always either contains, or generates ſome portion of gold. M. *Homberg* aſſures us, that taking a quantity of ſilver, and ſeparating it from all heterogeneous matter by a fuſion with lead; and after the fuſion, putting a piece of it in *Aqua fortis*; a little gold fell to the bottom. And upon adding ſome copper to the *Aqua fortis*, the ſilver was precipitated. *Its affinity with gold.*

Such are the properties of lead, hitherto diſcover'd: but a perſon, who had time enough to examine this metal more thoroughly, in a place where there were plenty of it to be had, at an eaſy price; as among the *German* mines; we have ſeveral reaſons to imagine, might diſcover many things therein, of a different kind from any thing yet known; and which might redound not a little to his advantage. *Our knowledge of it yet very imperfect.*

*Manner in which lead is found.* Lead is ſometimes found pure; but chiefly otherwiſe: and particularly in mines *, and chiefly thoſe in large mountains; of which kind there are abundance in *Germany*, *Hungary*, and *England*. Its ore †, or mineral, is a ſort of blackiſh, fatty earth, which makes it difficult to fuſe; but the fuſion being effected, the lead is pure without further preparation. The proceſs is thus:

*Method of ſeparating it from the ore.* The ore, or matrix of the lead being found, is ſtratified with coals, and ſo calcined, or fuſed with a vehement fire, till ſuch time as the coals have taken away all its ſulphur; which would otherwiſe prevent its malleability. What remains of the maſs, is lead ‖.

*Kinds of lead.* Lead is diſtinguiſhed into *common*, or *malleable lead*; which is what we have hitherto ſpoke of: and *black lead*, or lead of the philoſophers; which is *antimony*.

* The ore is of a poiſonous quality, eſpecially with regard to brutes: "They "who live near where it is waſh'd," ſays Mr. *Beaumont*, "can neither keep dog, nor "cat, nor any ſort of fowl; but they "all die in a ſhort time." He adds, that "not only calves, but even children have "been known to be kill'd, by only being "in houſes where lead-ore had been kept "ſome time: And that if any ſort of "cattel feed often on the graſs on which "the ſteam which riſes from the ſmelting "of lead falls, they all die ſoon after." *Phil. Collect.* N° 1.

Yet Mr. *Glanvil* informs us, from ſome experienced mine-men, that in the *Mendip* mines, the vein of ore has ſometimes been known to run up into the roots of Trees; without any obſervable difference in the top of ſuch trees from other. *Ubi ſupra.*

† There is a very conſiderable difference between the ores of different mines: "Some," ſays Mr. *Boyle*, "is ſo like ſteel, "that the workmen call it *ſteel-ore*; "which being of more difficult fuſion than "ordinary, they mix other ore with it. "There is another, which, from its aptneſs to vitrify, and ſerve to glaze the "potter's veſſels, is called *potter's ore*." *Uſeful. of Exper. Philoſ.*

The ſame author, elſewhere, reduces all our *Engliſh* lead-ores to three claſſes: The firſt, thoſe which in the ordinary ways of melting afford from thirty to forty pound of metal, for every hundred pound of ore. The ſecond, from forty-five to ſixty. The third, from ſixty to eighty. *Med. Hydroſtat.*

The lead of very many mines, being ſkilfully treated, affords ſilver; but the quantity of ſilver, in ores, does not hold in proportion to the quantity of lead. Mr. *Boyle* cauſed ſome lead-ore to be tried, which being the moſt promiſing he had ever known, gave him hopes of ſome conſiderable quantity of ſilver: but, tho' it prov'd ſo rich in lead, as to afford after the rate of ſeventy pound to the hundred; yet one of the moſt expert artiſts in *Europe* could not extract one grain of ſilver from it. *Uſeful. of Exper. Philoſ.* Yet a piece of lead-ore was brought him from *Ireland*, which ſeem'd ſo light in the lump, that he thought it ſcarce deſerved to be wrought for lead; which, however, was found, upon trial, ſo well ſtored with particles of ſilver, that he encouraged the owner of the mine to work it. *Med. Hydroſt.*

‖ In thoſe celebrated lead-works at *Mendip* in *Somerſetſhire*, the method of procuring the metal is thus deliver'd by Mr. *Glanvil*: "When they have got the ore, they "beat it ſmall, then waſh it clean in a "running ſtream; and then ſift it in iron "rudders: then they make a hearth or "furnace of clay, or fire ſtone, and therein build their fire, which they light "with charcoal, and continue with young "oaken gads, blown with bellows, by "mens treading on them. After the fire "is lighted, and the fire-place hot, they "throw the lead-ore on the wood, which "melts down into the furnace; and then "with an iron-ladle take it out, and caſt "it in ſand into any form they pleaſe." *Philoſ. Tranſ.* N° 39.

SIL-

# *S I L V E R.*

THE *first character* of silver, is its weight, which comes next to that of lead; being to that of gold, as 10 to 19; and to that of water, as 10 to 1. *Silver. Its weight.*

It falls short, therefore, of mercury, and consequently is but little disposed to become gold; unless we had a method to make it a great deal denser, and more compact. And hence it is that the alchemists hold it more easy to make gold of mercury, than of silver; and laugh at novices for attempting to convert silver into gold. *Not disposed to become gold.*

The *second character* is its fixedness in the fire; in which respect it goes beyond all known bodies, except gold *. *Fixity.*

This appears from an experiment of the prince of *Mirandula*, who placing a quantity of silver in the eye of a glass-furnace, kept it in continual fusion for the space of two months; then taking it out, found it to have lost only $\frac{1}{12}$ part of its weight.

Mr. *Boyle* even assures us, from experiments of his own, that silver, laid in the eye of a glass-house furnace, scarce loses any thing of its weight: tho', in an experiment made by Dr. *Halley*, after the silver had been in the focus of the furnace for two months, it was taken out with a diminution of $\frac{1}{12}$ of its weight; as in the prince of *Mirandula*'s experiment.

But 'tis highly probable, that the silver used in the first, and last of these experiments, was not pure; nor perfectly purged of tin: for Mr. *Boyle* taking out his silver at a fortnight's end, found it to have lost something: but after that, tho' exposed a long time to a very violent fire, he could not perceive it to lose any thing at all; the tin, which is exceedingly difficult to separate from silver, having been all carried off by the first fire **.

The third *property* is to be the most ductile, and malleable of all bodies after gold. *Ductility and malleability.*

* Mr. *Boyle* observes, that tho' silver be one of the most fixed of all bodies, it may be possible, by a mere change of texture, to render it volatile. To confirm this, he instances a calx of silver made by a solution of the metal in a peculiar menstruum, which, to his great surprize, upon exposing it over to a gentle heat, presently flew away in form of a *Farina volatilis*, whitening the neighbouring part of the chimney, &c. *Mechan. Orig. of Volatil. and Fix.*

** Silver, exposed to the focus of a large burning-glass, crackles, emits a copious fume, and is at length cover'd pretty thick with dust, or calx; which dust, if the silver have been refined with antimony, is of a yellowish cast, and by the further action of the solar fire, will vitrify like gold: but, if it have been refined with lead, the calx proves of a whiter dye, and never vitrifies. *Memoirs de l'Academ. A.* 1702.

Our wire-drawers uſe to ſtretch out ſilver to an incredible fineneſs; inſomuch that a ſingle grain, for inſtance, they will draw out into a thread of nine yards long; which thread is ſtill capable of being beat into a leaf two inches broad, and yet ſtill cohere.

*Fuſibility.* The fourth *property* is, that it eaſily diſſolves by fire; much more eaſily than either copper or iron, tho' more difficultly than either gold or lead; and runs e'er it ignites.

*Diſſolubility.* The fifth *property* is, that it is diſſolvable in *Aqua fortis*; and not in *Aqua regia* *.

*Aqua regia*, we have already deſcrib'd, with all the ſpecies thereof; and have ſhewn that *ſea-ſalt* is the baſis of 'em all. *Aqua fortis*, on the other hand, is always made of *nitre*; nor is ſilver diſſolvable in any ſaline menſtruum except what has nitre in it: not in ſea-ſalt, nor ſpirit of ſea-ſalt, nor *Aqua regia*, nor oil of vitriol, nor ſal-gem, nor ſal-armoniac, nor ſpirit of ſulphur *per campanam*, nor ſpirit of alum, nor vinegar, nor any other acid, or alcaline ſalt or juice. In effect, ſea-ſalt, ſal-gem, and ſalt armoniac are the only diſſolvents of gold; and nitre the only diſſolvent of ſilver. *In what menſtruums.*

Nitre fuſed by fire does not touch ſilver; but if it be mix'd with ſome body that prevents its liquefaction, and expos'd to a violent fire, it reſolves into fiery vapours, which being caught and condenſed in a receiver, is denominated *Aqua fortis*. *Aqua fortis, How prepared.*

In this diſtillation of nitre, the principal things added, to prevent its fuſion, are, 1. *ſand*, 2. *vitriol*, 3. *alum*, or, 4. *alum* and *vitriol* together. If ſome of theſe be not mix'd with the nitre, it readily runs; in which caſe, the fire acting equally on all the parts, does not change 'em ſufficiently, or convert 'em into ſpirit. But, when the fuſion is prevented, the parts of the nitre receiving more violent impreſſions from the fire, are exalted into a volatile ſpirit. Now alum and vitriol, when well dried, are not capable of being fuſed by any force of fire; and therefore mix'd with nitre ſuffice to prevent its melting.

If to the ſpirit of nitre thus diſtilled, be added ſea-ſalt, or ſal-armoniack; it will no longer diſſolve ſilver, but gold: and hence, if you would try whether *Aqua fortis* be pure; take a ſingle grain of it, and put a like quantity of pure ſilver, diſſolved in *Aqua fortis* therein. If, now, the ſolution remain without either the water's turning milky, or the ſilver's being precipitated; you may be aſſured the *Aqua fortis* is pure; for if it had the ſmalleſt grain of ſea-ſalt, or ſal gem, the liquor would become milky, and the ſilver fall to the bottom. *To prove its purity.*

* Yet M. *Homberg* has had the fortune to diſcover, by a happy miſtake, that *Aqua regia*, under ſome circumſtances, will diſſolve ſilver, and not gold. The phlegm which ariſes firſt in diſtilling *Aqua regia*, he obſerves, is a true *Aqua regia*, and yet this, if taken when newly made, and after it has been ſome time in digeſtion with gold, will diſſolve ſilver, without touching gold; tho' without theſe two circumſtances, it has the very contrary effect. *Memoir. de l'Academie*, *An.* 1700.

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Here ſeems, therefore, to be a ſort of natural repugnance; which is found of the utmoſt uſe; in regard that without it, we ſhould want a method of ſeparating gold from ſilver: 'tis true, they may be ſeparated by antimony; but then the ſilver all flies away and is loſt; and as for lead, it only ſeparates every thing elſe from gold and ſilver, leaving them together as it found them *: but diſſolve a maſs of gold and ſilver in ſpirit of nitre, and whatever falls to the bottom is gold, and what is retained is ſilver; or diſſolve it in *Aqua regia*, and what falls to the bottom is ſilver. *Its uſe in ſeparating ſilver and gold.*

The ſixth *property* is, that it reſiſts the force of lead, in the cupel; nor is at all hurt thereby, but comes out the purer. *Silver ſuſtains the force of lead.*

Thus if 100 pounds of pure ſilver be fuſed along with lead; the latter will all evaporate, or be blown away; and the ſilver remain behind without any diminution of weight.

The ſeventh *property* is, that it does not reſiſt the force of antimony; but volatilizes, and flies off along with it. *But not the force of antimony.*

Whence this ſhould proceed, is not eaſy to aſſign: antimony, we know, is corroſive, to a great degree; ſo great, that it volatilizes all metals, except gold; and carries 'em off in fumes. There is, therefore, a very notable difference between the nature of gold and ſilver; the former reſiſting lead, and every thing elſe; the latter, too, reſiſts lead, but not the lead of the philoſophers. And hence that denomination of antimony, *balneum ſolius regis*.

The eighth *character* is, that when well purified, it does not yield much ſound; being leſs ſonorous, and its ſound more obtuſe than that of iron, or copper; tho' more than that of gold. *Its ſound.*

Silver ** is ſcarce ever found pure, and free of all heterogeneous admixture: we meet with it in almoſt all ſorts of other minerals; ſometimes in the ore of gold, † ſometimes in that of lead, and that of copper, *In what forms it is found.*

* M. *Homberg* has hit on another way of ſeparating gold and ſilver; *viz.* by putting the maſs in a crucible, with equal parts of ſalt-peter and decrepitated ſalt at the bottom thereof, and ſetting the whole to fuſe in a melting furnace, by a gentle fire, for the ſpace of about a quarter of an hour.

The effect, he accounts for, by ſuppoſing the ſalts, e'er they be in perfect fuſion, to ſuſtain the mix'd metal, when it begins to melt, and ſerve as a kind of ſieve to it, letting the heavier part of the gold paſs thro', and retaining the lighter the ſilver, which does not fuſe ſo ſoon. So that if the crucible be taken from the fire at the proper juncture, the ſilver preſently hardens, &c. In the mean time, the ſalts being but imperfectly fuſed, prevent the ſilver's falling down and re-mixing with the gold. *Memoir. de l'Academie. Ann.* 1713.

** Moſt countries in all the quarters of the world, afford ſilver mines; but *Peru* and *Chily* above all others: the mines of *Potoſi* in particular are ſaid to be inexhauſtible; being dug now with almoſt as much ſucceſs as when at firſt diſcover'd; abating this, that the vein then lay, as it were, on the ſurface of the ground, but is now got to a frightful depth, being deſcended to by 4 or 500 ſteps.

† Mr. *Boyle* diſſolving ſome of the pureſt gold in a menſtruum, which he calls *peracutum*, found, at the bottom of the ſolution, a whitiſh powder, which being fuſed into a metal, prov'd true ſilver. And reducing the diſſolved gold into a body again, and diſſolving it a ſecond time; he procured more. Of *Forms and Qualities*.

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per; || but ofteneſt in a kind of black ſtony glebes, full of ſhining ſtreaks. It has *† a corroſive ſulphur, or bitumen, always found attending it; which turns yellow in the fire, and has ſomewhat of the effects of antimony; and perhaps has ſome antimonial parts in it, being found to volatilize the ſilver, in the cupel, and ſteal it away in fume: whence the alchemiſts denominate it *Fur*, *thief*.

*Always attended with a ſulphur.*

The loſs in this reſpect is very conſiderable; eſpecially if the maſs, or ore be very crude; ſo that the utmoſt care is to be taken in making the ſeparation: for a maſs of this kind being put in melted lead, the ſulphur will, indeed, be all carried off; but then the point is ſomewhat delicate; for if the fire be too intenſe, the ſilver is apt to go along with it; and if the fire be too ſlack, the ſulphur will be left behind.

*And hence the difficulty of procuring it.*

'Tis certain, many thouſand pounds worth of ſilver have been evaporated and loſt in the ſeparation; nor is there any thing more wanted in the art of metals, than ſome matter which would ſeparate ſulphur from ſilver, without diminution. The proceſs of ſeparating, which now uſually obtains, is thus.

*Deſideratum.*

## *Manner of ſeparating and purifying of* Silver.

*Silver ſeparated by torrefaction or calcination*

A Quantity of the ſilver glebe or ore is firſt torrified, or calcined in a furnace, by a gentle fire; ſtirring it from time to time; and taking care the fire be not ſo great as to melt and make the ſulphur carry away the ſilver.

|| See what has already been mention'd of the procuring of ſilver from lead, in the *notes*, *p.* 82.

A friend of Mr. *Boyle*'s brought him ſome ore, found in his own grounds, which appear'd to be copper ore; as indeed, after fuſion, it did yield a very good copper; but the perſons to whom he committed the examination of the mine, being very ſkilful, found in the ore, not only copper, but in the copper a conſiderable quantity of ſilver, and in the ſilver a good proportion of gold.

'Tis not eaſy to determine, whether the gold and ſilver thus obtain'd from divers matters, were really contain'd therein, or are made by the operation. A man would ſcarce imagine that there were iron in plants, and yet their aſhes afford ferruginous corpuſcles which the load-ſtone attracts. But of this we have ſpoke more at length in the *notes*, *p.* 60.

*† The mineral ſtones dug out of the mines of *Peru* are of different colours, qualities, hardneſſes, &c. ſome are white, or greyiſh mix'd with red or blueiſh ſpots, call'd *Plata blanca*; others black, call'd *Plomo ronco*, which is the richeſt and the eaſieſt wrought. The *Roſſicler*, tho' rich, turns red when rubb'd againſt iron. The *Zorock* ſhines like talc. The *Paco* is of a yellow red, extremely ſoft. The *Cabriſſo* green, and almoſt friable. Laſtly, the *Arannea*, which is no where found, but in a ſingle mine at *Potoſi*, conſiſts of threads of pure ſilver, interwove ſomewhat like a ſilver-lace that had been burnt for the ſilver.

The working of theſe mines, is exceeding dangerous, on account of the exhalations they yield; which are even felt a good diſtance off; and not only ſuffocate the miners, but even the cattle grazing in the neighbourhood. Scarce any of the workmen can bear ſo peſtilential an air above a day together. It ſometimes proves ſo mortal, that they are oblig'd to ſtop the mines up again. The mines of *Potoſi* are reckon'd the moſt innocent; and yet it were impracticable to work even theſe, but for the herb *Paraguay*, an infuſion whereof, taken much as Tea is among us, ſerves for a ſort of preſervative

ver. The ſulphur thus inſenſibly conſumed; they grind the maſs into a powder; and caſt huge quantities of rain-water thereon; taking care to ſtir and agitate it ſufficiently to ſeparate all the lighter parts, and make 'em ſwim a-top. After it has ſtood a while to ſettle, they pour off the water, with all that was ſuſtain'd therein; and pour on a freſh quantity: this they ſtir, and throw off as before; repeating the proceſs till all the lighter, earthy matters are clear'd off, and nothing left at bottom but metal, with the heavier ſtones, *&c.* *Lotion.*

To ſeparate theſe, they put the maſs into melted lead, over a fire ſufficient to carry off the remaining ſulphur, yet not ſo intenſe as to carry the ſilver along with it; and as mercury has a property of drawing ſilver to it ſelf, they add a quantity of hot mercury to the melted lead: by which means the whole metalic matter becomes amalgamated, or fix'd in a maſs, excluſive of the ſtones: tho' the ſulphur muſt all have been well clear'd out in the firſt place; otherwiſe the mercury will not attract the ſilver, but diſſolve and mix with the ſulphur, and form cinnabar. *Addition of lead and mercury* *Amalgamation.*

The next ſtep is to dilute and grind this amalgama, or maſs of mercury and ſilver, in water; then they diſtil it in a retort; by which means the mercury all riſes and evaporates, and the pure ſilver remains in a powder at bottom. *Diſtillation.*

By the like method it is eaſily found whether, or no, there be any ſilver in a given maſs. Some, inſtead of calcining the ore, to conſume the ſulphur, grind it up with iron filings; and when in fuſion, caſt in ſome fix'd ſalt, which drawing and abſorbing the ſulphur, goes off in ſcoria, and leaves the metal alone*.

*COP-*

* In the ſilver works of *Peru* and *Chili* the method of ſeparating the ſilver is ſome what different. After firſt breaking, and then grinding the ore by a water mill, they ſift it in iron riddles, and mix it up with water, into a paſte: This, after half drying it, they cut out into ſquare pieces of about 2500 *lib.* each, call'd *Cuerpos*; and bake 'em over again with ſea-ſalt, which melts and incorporates therewith. This done, they ſprinkle mercury on 'em, and bake 'em a third time, till the mercury be well incorporated with the whole ſubſtance of the ſilver. This operation, which is exceed ingly dangerous, falls to the ſhare of the poor *Indians*, who go to it eight times a day. To promote the effect of the mercury, they add lime and lead, or tin ore, and in ſome places even make uſe of fire.

When the amalgamation is compleated, they carry the maſs to the *Lavaderos*, which are three baſons, placed a-ſlope, ſo that they empty ſucceſſively out of one into another: the *Cuerpos* being thrown into the uppermoſt, and the ſtream of a rivulet turn'd upon it, the lighter, earthy part, is ſeparated and carried off; which is forwarded by an *Indian* treading all the while upon the maſs. When the water goes off clear, the ſilver is found at bottom, incorporated with the mercury; in which ſtate it is call'd *Pella.* To get out the mercury again, they put up the *Pella* in woollen bags, preſs it hard, pound it lightly, and at laſt full it in a ſort of wooden mould, or trough, perforated at bottom like a cullender; and now the maſs is call'd *Pinea.*

The *Pinea* being taken out of the mould, is then laid on a copper plate full of holes, over a trevet, under which is a large veſſel of water; and the whole cover'd with a capital of earth, which they ſurround with fire. By this means, the mercury remaining in the *Pigne*, is firſt volatiliz'd,

## *COPPER.*

*Copper.* *Its weight.* THE first *character* of copper, is, its ſpecific gravity; which, as already noted, comes next that of ſilver; being to that of gold as 8 to 19, to that of water as 8 to 1, and to that of ſilver as 8 to 10.

*Ductility.* The ſecond *character*, is, that when pure, it is very ductile, * and of a beautiful red colour, exceeding that of gold. We are not here ſpeaking of the yellow copper, called braſs, and *aurichalcum*, which is a factitious metal prepared of copper melted with *Lapis calaminaris.*

*Fixity.* The third *character* is, that it continues long fix'd in the fire, e'er it flies off; almoſt as long as ſilver; much longer than either lead or tin: tho' at length it evaporates, and loſes much of its weight.

*Fuſibility.* The fourth *character* is to be difficult of fuſion; much more ſo than ſilver: and yet it ignites before it fuſes; the contrary of which happens in ſilver.

*The danger that attends the fuſion.* It muſt not be omitted, that if, when copper is fuſed, a ſingle drop of water do but fall upon it; or if the moulds, veſſels, &c. it is caſt in, be but ever ſo little moiſt; it flies into a million of fragments, with an incredible noiſe, and deſtroys all the perſons near it. For this reaſon the *Swediſh* miners are very cautious of admitting any body to be preſent at the operating; leſt chancing to ſpit, ſneeze, or the like, they bring inſtant deſtruction on 'em all.

*Diſſoluble by all ſalts.* The fifth *character* is to be diſſoluble, by all the ſalts known; both acid, alcaline, and nitrous; nay even by water, air, &c. conſider'd as they contain a proportion of ſalt.

*Ærugo.* The diſſolution ſhews it ſelf by an *ærugo*, or ruſt covering the metal; which when view'd with a microſcope, appears a congeries, or cluſter of cryſtals, of different colours, according to the ſalt that produc'd 'em: thus copper ſuſpended in the vinegar-houſes immediately contracts a ruſt, and grows green; and the ſame is effected by common and other ſalts, which

liz'd, and rais'd; and then precipitated again into water, where condenſing, it forms a number of grains of ſilver of different figures, ſticking to each other. And 'tis in this form, the workmen endeavour clandeſtinely to ſell the ſilver to foreign veſſels, trading in the *South Sea. Dict. de Commerce.*

* The extreme diviſibility of copper exceeds all imagination; Mr. *Boyle* making a ſolution of a ſingle grain of metal, in ſpirit of ſal-armoniac, found it would give a blue colour to 256806 times its own bulk of clear water; nay, a manifeſt tincture to above 385200; and a faint, yet diſcernible one, to above 530620 times its bulk. *Subtil. of Effluvia.*

Mr. *Boyle* aſſures us, that by the help of zink, duly mix'd after a certain manner, he has given copper as rich a colour as ever he ſaw in the beſt gold. *On Colours.*

‖ To make braſs, they calcine, and pulverize the calamine, then mix it with a little charcoal duſt: ſeven pound of this mixture, they put into a melting pot, with about five of copper over it. Then, letting it down into a wind furnace; after 11 hours it is drawn up again; the braſs being compleat.

being

being ſprinkled over the moſt poliſh'd copper plate, turn it ruſty in a day's time. Nay, oils themſelves diſſolve copper; witneſs oil of olives, *&c.* but it muſt be added, they do this by means of the ſalt contain'd in 'em*.

Add, that if melted ſugar, ſaliva, a ſyrup, *&c.* do but touch copper they diſſolve it, and become vomitive.

Copper diſſolved by acids, turns green; by alcalies, red; and by the intermediate ſalts, blue. *Different colour of its ſolution.*

If the ruſt be held to the fire, till the diſſolvent is dried and evaporated; it grows blackiſh, and is call'd the *calx* of copper.

From this common reception of all menſtruums, copper is call'd by the chemiſts † *Venus*, i. e. *meretrix publica*, a common proſtitute. All other metals have their peculiar diſſolvents, but this is diſſolved by all. *Whence the name Venus.*

The ſixth *character* is, not to reſiſt either lead, or antimony; but, if long expos'd to the fire, in the cupel, to fly off with 'em, and diſappear. *Copper volatiliz'd either by lead or antimony.*

The ſeventh *character* is, that of all metals it is the moſt elaſtic, and ſonorous; and on that account is commonly us'd for the ſtrings of muſical inſtruments, as alſo for trumpets, *&c.* *Its elaſticity and ſound.*

The eighth *character* is, that it remains long fix'd in the fire; tho' at length it emits a white poiſonous fume, and loſes a deal of its ſubſtance. *Fixity.*

'Tis a thing of the laſt importance to a phyſician, to be well acquainted with the nature and properties of copper; as it furniſhes a great variety of remedies, for various occaſions. *Medicinal virtues of copper.*

It may be even ſaid, that all which *Paracelſus*, *Helmont*, *Boyle*, &c. have laid down of an univerſal remedy, ſeems underſtood of copper.

Thus the famous *Butler*'s ſtone, if there be any truth in it, was compos'd of a preparation of this metal: that much celebrated remedy of *Van Helmont* is known to be no other than ſulphur of vitriol or *Ens* of vitriol, fix'd by a long calcination and cohobation. Mr. *Boyle*'s *Ens Veneris* is made of *Ens* of vitriol of *Venus* reſtor'd by ſal-armoniac. It cannot be denied that copper is an excellent emetic, having this ſingular virtue, that it exerts its force as ſoon as ever 'tis taken; whereas other emetics lie a long time dormant in the ſtomach, creating nauſea's, anxieties, *&c.* But a ſingle grain of verdigreaſe immediately vomits; and hence, ſyrups, *&c.* which have ſtood all night in copper veſſels, excite vomiting. 'Tis alſo of excellent uſe for deterging of old ulcers; and of approv'd virtue in chronical and hydropical caſes; accordingly we read, that a celebrated phyſician recover'd *Charles* V. of a dropſy, by the mere uſe of copper. In effect, when its vomi- *Butler's ſtone. Ens Veneris.*

* Mr. *Boyle* found that oil of ſweet almonds, nay even milk it ſelf, would make a kind of diſſolution of crude copper. *On corroſiveneſs*, &c.

† Others will have the name *Venus*. more immediatly referr'd to copper, from its faculty abovemention'd, of turning *green* with all *males*, i. e. all acid ſalts; the chemiſts calling all acids, males; and alcalies, females.

tive virtue is ſpent in the body; it acts by its ſulphur; which is of a very penetrating nature, and highly narcotic, aſſuaging pains, &c.

*Where copper is found.* Copper is found in divers places, both in *Europe*, *Aſia*, and *America*; but the moſt abundantly in *Sweden*, and *Germany*; where there are whole mountains of it. Indeed, it may be obſerv'd in the general, that there is ſcarce any earth, in any part of the globe, but what has a ſhare of copper in it. 'Tis ſometimes found in ſubſtance, but oftner in hard ſtony glebes*.

The richeſt copper mines are in *Hungary*; where the mineral matter contains $\frac{1}{5}$ part of pure copper.

Wherever copper is found, there is always found vitriol; and that generally of all the three kinds, *viz.* green, blue, and white; and hence the claſs of *vitriols of Venus*, or *copper*. Along with copper are likewiſe found the richeſt and brighteſt-colour'd gems, as emeralds, turquoiſes, and the like green and blue precious ſtones.

## *Separating of* Copper *from the Ore.*

*Difficulty of ſeparating it from the ore.* THe procuring, or ſeparating of copper from its glebe or ore, is very difficult; to which difficulty it is, that the great price the metal bears, is wholly owing. For 'tis found in ſuch abundance, that were it not for this, it might be ſold for almoſt nothing: but it adheres ſo ſtrongly to the ſtony matter, that 'tis a wonder it ſhould ever be ſeparated at all.

*Ercherus* ſays it muſt paſs thro' 14 furnaces † e'er it be pure. So long as any of the ſtony ſubſtance adheres to it, it remains friable: But a portion of that is ſeparated and caſt off at every fuſion; till, at length, after the fourteenth fuſion, it is all extracted, and the metal left red, and malleable.

* Copper ore is ſometimes, alſo, found in form of a duſt, or powder; and ſometimes procured from the water of certain rivers. The ſtony glebes, again, in which it is ordinarily found, are of different qualities, ſome blue, others green, &c. In the mines of *Hungary*, Dr. *Brown* obſerves, there are divers ſorts of ore, but the chief difference is between the yellow and the black; the firſt whereof is pure copper ore, the black alſo contains a portion of ſilver. *Phil. Tranſact.* N° 59.

† E'er they go to fuſion, they firſt waſh it well, to ſeparate the looſer earth; and when fuſed, caſt it into moulds call'd ſalmons. What is obtain'd by the firſt melting, is the copper commonly uſed: for particular occaſions, they have recourſe to repeated fuſions. According to the different matters wherewith the metalline part is combin'd, different things are added to the ore, in fuſing, to carry off the ſame.

In the *Hungarian* mines, Dr. *Brown* tells us, they ſometimes burn the ore, and ſometimes melt it; and this, ſometimes by it ſelf, and ſometimes mix'd with other minerals, and its own droſs. He adds, that an hundred weight of ore will yield 20, 30, 40, nay 50, and 60 pound of metal. *Phil. Tranſact.* N°. 59.

IRON.

# *IRON.*

THE *first character* of iron is, that it is the heaviest of all bodies, after copper. *Iron. Its weight.*

Its *second character* is, to be the least ductile, the hardest, and most brittle of all metals. *Brittleness.*

Yet, by fusing it, we can render it still harder, and more brittle, and scarce capable of being drawn or extended at all: or, if it be only ignited, and then quenched in cold water, it grows harder, and loses much of its former degree of ductility; and the more so, as the water is colder, and denser, and the extinction more sudden.

This extraordinary brittleness of iron arises from the great quantity of sulphur intermixed with it: we find a degree of sulphur in all metals: and the greater that degree, the more brittleness does it impart to the metal. The abundance of sulphur in iron is apparent from the sparks it emits, when ignited, and beat under the smith's hammer; those sparks being only the sulphur of the iron: nor is there any thing like them seen in any other metal. *Whence that arises.*

Iron being well purged of its sulphur by a vehement fire, becomes harder, compacter, and somewhat lighter, and is called steel *. *Steel.*

The *third character* is, that it is very fixed; we mean as to its metalline part, not its sulphureous one. This *Fixity of iron.*

* The business of steel remains somewhat obscure: the naturalists, from *Aristotle* to our time, speak of the making it, in terms which leave a man greatly to seek for the precise method thereof. It seems the artists have had the address to elude their inquiries; and still keep somewhat of the mystery with themselves.

*Aristotle* says, *That steel is only iron defecated, and made pure by repeated fusions; for the impure parts, or* scoria, he observes, *subside, and are purged off by the bottom.* Meteor. l. 4. c. 6. And the like account is given by several later writers. But Dr. *Lister* shews they are all mistaken: iron, of itself, he notes, how oft soever purged, and refined, will never become steel, without other addition. *Philos. Trans.* N° 203.

The chemists, with the generality of later writers, as Dr. *Plott*, &c. will have steel made by keeping the iron ignited some time, amidst the fire, and fume of bullocks horns and hoofs, and charcoal made of beech, or willow; and then plunging it in cold, astringent decoctions. But these additions appear to be no better than a blind; they are necessarily required for *case-hardening* of iron, which may have led authors into the notion; but don't contribute any thing to the converting it into steel.

*Kircher*, and *Agricola*, describe the method of making steel, as practised in the island of *Ilva*, a place famous from antiquity for this metal: "The iron is first heated red-hot, "then cut in small pieces, and thus mixed "with a sort of stone which promotes the "fusion: then, a crucible is set in a "smith's forge, and fill'd with charcoal. "When the vessel is red-hot, they put in, "by little and little, the mixture of iron "and stone. As soon as 'tis melted, they "thrust three or four pieces of iron into "the middle thereof, and keep them boiling therein, by a strong fire, five or "six hours; observing, from time to time, "to stir the melted metal, that the pieces "of iron may imbibe the smaller, subtiler "particles thereof, and have their own "grosser particles attenuated thereby. "Lastly, taking out the pieces, they forge "them, and draw them out into bars; "and thus, hot as they are, plunge them "into cold water: taking them out from



"hence,

This latter is pretty eaſily volatilized, and conſumed by fire, as appears from the ſulphureous ſmell of iron, either ignited, or melted. If you expoſe iron to an intenſe fire, it grows warm, reddens, commences of a flame-colour, and at length emits ſparks, and then runs. If it be now taken away, it will be found ſofter for the fuſion: but if you continue it in the fire, it comes at laſt to yield a whitiſh fume; and thus loſes a great part of its body, *viz.* all the ſulphur.

*Fuſibility.* The *fourth character* is, that it ignites long e'er it fuſes; and fuſes with much difficulty: and that, contrary to the nature of all other metals, the more it is ignited, the ſofter, and more ductile it becomes; being ſcarce flexible or malleable at all, till after ignition.

Add, that when in a ſtate of ignition, both its weight and dimenſions are greater than when cold *. This acceſſion of weight ariſes, no doubt, from the fiery particles fixing therein: and if, when ignited, it be prevented from extending itſelf, it burſts; and either breaks, or throws off any body that reſtrained it.

*Diſſolubility.* The *fifth character* is, to be diſſoluble by almoſt all bodies in nature; all, we mean, that have any degree of activity, as ſalt, dew, the breath, fire, water, air, &c.

*Its ruſt.* By the action of any of theſe, it contracts a *rubigo*, or *ruſt*; which is nothing but the flowers of iron; or iron diſſolved, and relinquiſhed by its diſſolvent: for iron, being examined in a miſcroſcope, when firſt it becomes ruſty, ſhews its ſurface cover'd over with a number of pellucid, vitriolic *lamellæ* or glebes; which being afterwards dried, by the fluid menſtruum's evaporating, become a ruddy calx.

*How prevented.* Hence, a fatty, or oily matter, perfectly deſtitute of all ſalt, or acidity, being ſmeer'd over iron, hinders its contracting ruſt; by preventing the acceſs of the air, and water; the ſalts floating wherein, would corrupt it.

And hence the method uſed by our artificers to preſerve iron pure, and bright; *viz.* by boiling oil of olives with a little litharge, or ceruſs; by which the acidity of the oil is abſorbed: or, they only boil their oil to a thickneſs; and ſo exhale the acid.

" hence, they are found ſteel; tho' not " ſo perfect, but that they frequently make " them undergo the proceſs a ſecond time; " firſt caſting in ſome freſh matter into " the crucible." *Agric. de Re Metal.* lib. 9.

Upon the whole, we may obſerve, that the charcoal appears the moſt eſſential thing in the operation, as being the only conſtant ingredient in each method: accordingly, we have even reaſon to apprehend it the only eſſential; as having ourſelves made tolerably good ſteel by only keeping the iron in a crucible fill'd up with mere charcoal-duſt, in a briſk fire, for the ſpace of about a quarter of an hour.

* M. *Muſchenbroeck*, counterpoiſing a priſm of iron of three pound weight in a nice pair of ſcales, which would even turn with $\frac{1}{20}$ of a grain; and afterwards heating the priſm red-hot, found that it ſtill weigh'd exactly three pound: whence he concludes, that it had gain'd in weight from the fire. For the experiment being made in open air; and heat being always found to dilate iron; 'tis evident the ſpecific gravity of the metal muſt have been diminiſhed by ſuch dilatation: which muſt have been perceived by the ſcales, unleſs ſome new weight had been added to it from another quarter. *De Materia Subtil.*

By

By an intimate ſolution of iron with water, it is that the famous preparation *Crocus Martis*, or ſaffron of iron, is made. In effect, all ſalts, both acid, alcalious, and intermediate, ſimple and compound, have a like effect on iron. And hence that elegant experiment of taking a large plate of iron, and applying to it, in one place, a drop of water ; in another, a drop of vinegar ; in another, a fixed ſalt ; in another, volatile ſalt : for all theſe ſeveral ſalts will bring a ruſt on the metal ; but a differently colour'd ruſt, according to the menſtruum. Crocus Martis.

The *ſixth character* is, that it neither reſiſts the force of lead, nor antimony, nor fixed ſalt ; but being fuſed with them, readily diſſipates into fume, or vitrifies. *Iron render'd volatile either by lead or antimony.*

The *ſeventh character* is, to be very ſonorous, and elaſtic ; tho' the ſound it yields is leſs ſweet than that of copper. *Its ſound.*

The *eighth character* is, that of all bodies it is the only one attracted by the load-ſtone *. *Attracted by the load-ſtone.*

Iron is found in moſt parts of the globe ; nay, even in all ſorts of matter : particularly, all the parts of animals, both ſolids and fluids ; as milk, urine, blood, fat, bones, fleſh, &c. Out of any of theſe, iron is eaſily procured, by calcining them, and then drawing a load-ſtone, or the edge of a knife touch'd with a load-ſtone, lightly over the calx or aſhes : for the iron particles are by this means drawn out of the aſhes, and ſeen to adhere to the knife. *Iron found in all places, and all bodies.*

Again, all earths calcined, contain iron ; as we ſee in clays, and potters earths ; it being the iron alone that gives them their reddiſh colour, when burnt, or baked. The ſame is obvious of bricks, tiles, &c. which are

* But it muſt not here be forgotten, that iron itſelf may be brought to attract iron ; or that it may become a magnet with reſpect to itſelf. Dr. *Gilbert* obſerv'd long ago, and Mr. *Boyle* confirms the obſervation, that iron-rods, as the bars of windows, by ſtanding a long time in a perpendicular poſition, will grow magnetical : ſo that the bottom of the bar will attract the ſouthern end of an animated needle, and repel the northern ; but the upper end attract the northern, and repel the ſouthern.

Mr. *Boyle* has even found, that a bar of iron, without ſtanding long in an erect poſture, by merely holding it perpendicularly, will acquire the ſame virtue ; but then the virtue will be tranſient ; ſo that if you do but invert the bar, its poles will be changed.

The ſame author obſerves further, that the ſame virtue which a bar of iron acquires in a long courſe of time, merely by its poſition, may be ſoon imparted to it by means of fire. And hence we find, that the ſame experiment holds in tongs, and other iron utenſils, which have been ſet to cool, leaning againſt the wall.

And hence, probably, the ſtory current among the *Italian* naturaliſts, *viz.* that a large iron bar, ſupporting a croſs of an hundred pound weight, on the top of the church of *Aramini*, was tranſmuted into an actual load-ſtone : a piece of which was preſerv'd, among other rarities, in the repoſitory of *Aldrovandus*.

Mr. *Boyle* adds, that having brought a large piece of *Engliſh* oker to a proper ſhape, and then made it red-hot, and let it cool again in an erect poſture ; it diſcovered a magnetical virtue ; and would attract one end of a needle, and repel the other. *Mech. Prod. of Magnetiſm.* But whether this laſt caſe be not accountable for from the ferruginous matter wherewith that mineral is known to abound, even beyond ſome *iron-ores*, contain'd in the oker ; will admit of ſome doubt.

made of a bluiſh, livid clay, and only become red in virtue of the iron particles mix'd with them *.

*Iron ſuppoſed the baſis of the ſtone in the bladder, &c.* The learned Dr. *Liſter* imagines he has diſcovered that iron is the baſis of the ſtone in the bladder, and kidneys ; and, conſequently, that the more we eat of vegetable and animal ſubſtances containing ſuch iron ; or the more chalybeats, or iron medicines we take ; the more matter is ſupplied for the generation of that diſtemper.

*And on what grounds.* The foundation of this doctrine, which is now very current among the *French*, is that experiment above-mentioned of iron drawn out of the calx of human urine, or milk, or blood, or bones, or the ſtones themſelves extracted from animals. But tho' thus much be allow'd true ; yet ſtill it may be doubted whether it be iron that generates the calculus. For when *The weakneſs thereof.* iron has contracted a ruſt, it is ſcarce attracted by the load-ſtone at all : ſo that it is a little preſumptuous to argue thus : " All vegetable, and animal " matter afford a calx which is attracted by the load-ſtone ; conſequently, " the iron we take, furniſhes the matter of the ſtone :" Since iron itſelf, if corrupted by a ſalt or acid, or even by heat, does not act on the magnet. That excellent author, therefore, has carried the point a little too far : And accordingly, all he has wrote, on this principle, about ſpaw-waters, and chalybeat medicines, muſt be look'd on as very precarious, and hypothetical at beſt.

## *Separating of Iron.*

*Iron, how found, and ſeparated.* IRon is rarely found under its own form ; but moſt commonly in black or brown glebes ; from which it is never ſeparated by mere fire alone ; but ſome other menſtruum is neceſſarily uſed, to abſorb the ſulphurous *By calcination, and fuſion.* part. For this reaſon, the beſt way is to calcine the mineral glebe, by ſtratifying it with coals ; and then to fuſe, or melt the calx down by a violent fire. By this means, the metal is brought out fluid like water, and re-

* Iron-mines are common in moſt countries of *Europe* ; *Norway*, *Poland*, *Germany*, *France*, *England*, &c. abound with them : only *America*, which is ſo plentiful of gold and ſilver mines, has none of iron : and, accordingly, the natives prefer a metal of ſo much uſe, infinitely beyond their own treaſures. In ſome mines in *Sileſia*, M. *Sthall* obſerves, they find grains of iron, already malleable. Mr. *Boyle* adds, that one of the beſt ſorts of *Swediſh* iron is found in form of a mud, at the bottom of lakes, and other ſtagnant waters.

Its common glebe, or marcaſſite, bears a near reſemblance to the load-ſtone : as, in effect, that ſtone always yields true iron. Sometimes it is in pieces as big as the fiſt ; and ſometimes only in a ſand. Again, in ſome places, it is in the very ſurface of the earth, ſcarce an inch or two deep ; but 'tis more common to have it at a depth of four, five, or ſix feet.

The foreſt of *Dean*, in *Gloceſterſhire*, is particularly rich in *iron-ore* ; which it yields of divers colours, weight, &c. The beſt is that of a bluiſh colour, heavy, and full of ſhining ſpecks, like grains of ſilver : but this, tho' it yields the greateſt quantity of iron ; yet, being melted alone, the metal is too ſhort and brittle. To remedy this, they mix it with the *cinder*, or remains of old ore melted down long ago ; which gives it that excellent temper and toughneſs for which this iron is ſo much prefer'd to any other. *Philoſ. Tranſ.* N° 137.

receiv'd in moulds of different forms, according to the works it is intended for *.

*Medicinal virtue.* Iron [*Mars*] is one of the nobleſt remedies all medicine affords; of more efficacy, in chronical caſes, than all animal and vegetable matters put together. 'Tis greatly ſtrengthning, and aperitive, or aſtringent, or ſtyptic, as 'tis differently prepared †.

* In the *iron-works* at *Milthrop* in *Lancaſhire*, they uſe turf along with the charcoal, which makes the iron better than the coal alone. Beſide, to the calx thus produced, they add about $\frac{1}{16}$ of the quantity of lime-ſtone unburnt, to make it melt more freely and caſt the cinder, which they take off before they let the metal run. *Philoſ. Tranſact.* N° 199.

† The compoſition of iron we have already touch'd on in the *notes*, p. 60. But there remain ſome things on that head yet behind. *Van Helmont*'s ſon, it ſeems, had a method of making iron with mud, and ſulphur: The ſecret, *Becher* could never get out of him; but chance threw him on another, which he thus deſcribes: Take clay, form it into little balls with linſeed-oil, and lay them in a retort; urge them with a violent fire; and, after diſtillation, there will remain blackiſh globules, which, when ground and waſh'd, will be a heavy matter, which the load-ſtone attracts. M. *Herman*, profeſſor at *Erfort*, accidentally made iron by the falling of ſome clay, wherewith a hole in a retort was ſtopp'd, upon the *caput mortuum* of ſome alum and ſea-ſalt, which he was drawing the ſpirit from. Laſtly, *Sthall*, going to prepare ſome volatile ſpirit of vitriol; by miſtake took a maſs of alum, and common ſalt, inſtead of vitriol. The effect was, that, after the operation, he found a blackiſh matter; which, when waſh'd, appearing to be very heavy, he preſented the load-ſtone to it, but in vain: yet, after expoſing it to a large burning-glaſs, he found it was become real iron, and readily flew to the magnet. He adds, that ſome of the maſs which he took at firſt, gave no ſigns of iron, tho' long expoſed to the burning-glaſs; and even, that tho' he poured a vitriolic ſpirit thereon, yet no vitriol was produced: which is a ſtrong preſumption that there was no iron in it then; for a martial earth, with the addition of a vitriolic ſpirit, never fails to afford vitriol. *Nouv. Cours de Chym.*

# *TIN.*

*Tin.* THE *firſt character* of tin is, that it is the lighteſt of all metals; tho' the heavieſt of all bodies, except metals.

*Its weight.* There are divers kinds of tin, which are each accounted the better as they are heavier; but of all others, that call'd *block-tin* is the moſt valued.

*Softneſs.* The *ſecond character* is, to be very ſoft; more ſo, than any other metal, except lead.

'Tis alſo greatly ductile, and very little elaſtic; leſs than any other metal, except pure gold, and ſilver.

*Volatility.* The *third character* is, that of all metals, it is the leaſt fix'd in the fire, and affords the greateſt quantity of ſulphurous fumes; and, conſequently, loſes moſt weight in the fire.

We have made divers experiments to this effect; the reſult of which puts the common obſervation of almoſt all the alchemiſts paſt doubt; *viz.* that tin will emit fumes even by the moſt gentle fire. The fume thus emitted, is the mere ſulphur of the metal; accordingly, the more the ſulphur is conſumed, the lighter ſtill it grows.

*Fuſibility.* The *fourth character* is, to be fuſible by any the moſt gentle fire; and that long before ignition: tho' the purer the metal, the more difficultly it fuſes. Add, that when urged even by an eaſy fire, it ſhines exceedingly; but this ſplendor is ſucceeded by a poiſonous, ſulphureous ſteam, very deſtructive to the lungs; as thoſe who are employ'd in melting tin, find to their coſt; it uſually giving them a pale, ghaſtly complexion, and throwing them into a phthiſis.

The evaporation being over, there is left a cruſt, or calx, called *calx of tin*; which being expoſed to a very violent fire, becomes volatile, and flies entirely off *.

*Miſcibility with other metals.* The *fifth property* is, that it eaſily, and intimately mixes with other metals, as gold, ſilver, *&c.* and that it diminiſhes their ductility †, and gives them a degree of brittleneſs: whence, again, it is evident, it contains a great deal of ſulphur.

If this ſulphur could be perfectly purged out of tin, 'tis likely it would be found no other than ſilver: for as it is, the two metals have ſeveral properties in common. Thus, when diſſolved in ſtrong acids, tin grows

* Yet tin, thus calcined, and even volatilized, is again reducible into its metalline form. Thus Mr. *Boyle*: Tho' tin, in our reverberatory furnace, be uſually only brought to a calx, which is reputed very fix'd; yet in thoſe intenſe fires, an acquaintance of mine uſes in his tin-works, quantities of this calx are carried up to a conſiderable height, where it gathers into whitiſh maſſes; which, by a skilful reduction, yields great quantities of good malleable metal, rather finer than the ordinary tin. *Mechan. Orig. and Prod. of Volatil. &c.*

† Yet iron muſt be here excepted; that metal being render'd more malleable by a mixture of tin. *Nouv. Cours de Chymie.*

bitter,

bitter, as well as ſilver; and when it is fuſed along with ſilver, it adheres ſo obſtinately thereto, that there is ſcarce any ſeparating them. Add, that under ſuch circumſtances it reſiſts lead, almoſt as much as the ſilver does. And hence many account it an impure ſpecies of that metal *.

In effect, we have inſtances of ſilver's being actually made of tin; but not pure ſilver: Beſide, that it has been made a capital crime to ſell ſuch ſilver; which has diſcouraged people from improving on the method †.

The *ſixth property* is, that acids do not diſſolve it without much difficulty, eſpecially the more powerful ones. *Hardly diſſoluble in acids.*

The reaſon hereof is apparently its abounding in ſulphur; which acids, we know, do not touch. Add, that it diſſolves in *Aqua regia*, ſcarcely in *Aqua fortis*; which is a circumſtance remarkable enough, conſidering the near alliance it has with ſilver.

Again, the weaker the acid *menſtruum* is, the ſooner, and the eaſier it works its end; and the ſtronger, the more ſlowly: thus, ſour apples, and other unripe fruits, by being boil'd in tin-veſſels, will grow ſweetiſh; *Eſpecially the more powerful ones.*

* It may admit of ſome doubt, whether tin bears theſe reſemblances to ſilver, in virtue of its being tin, or only in virtue of the particles of ſilver mixed therewith. 'Tis certain, more of theſe reſemblances, and thoſe in a greater degree, are found in ſome ſpecies of tin than others. Mr. *Boyle* mentions a gentleman, who having procured a good quantity of the nobler metals from ſome *tin-ore* long digeſted in lixiviate liquors, deſired Mr. *Boyle* to purchaſe him a large quantity thereof; in full expectation of raiſing an eſtate. But, ſays Mr. *Boyle*, after his firſt ſtock of ore was ſpent; the next that he procured, tho' managed with the ſame care as the former, proved wholly unprofitable. *Uſeful. of Exper. Philoſ.*

The ſame author relates, that having diſſolved ſome *block-tin*, (for ſo the workmen call that which is pure and unwrought) in a particular *menſtruum* which kept it ſuſpended; and having afterwards evaporated the ſolution, and ſet it to ſhoot; he found, to his ſurprize, that the cryſtals it afforded were not at all like its own kind of vitriol, but broad, flat, and thin, like thoſe of ſilver: upon examining them farther by the tongue, they had nothing of the taſte of calx of tin made in ſpirit of vinegar; but that exceſſive bitterneſs we meet withal in the cryſtals of ſilver made with *Aqua fortis.* He adds, that finding this further reſemblance betwixt the ſalts of thoſe two metals, that both of them preſently tinged the nails and ſkin with a black that would not eaſily waſh off; he ſhould have ſuſpected that the *menſtruum* had exalted the metal into an affinity with ſilver; had he not afterwards proſecuted the ſame trial with the ſame *menſtruum*, and another parcel of block-tin; and found, that tho' this metal was bought at the ſame place, and very ſoon after the other, yet the former ſucceſs was owing to his having lighted of a lump of tin that was of a peculiar nature. *Uſeful. of Exper. Philoſ.*

† Some authors ſpeak much of the analogy between tin and lead; and will have tin to be lead, only under a leſs degree of coction: but if there be ſome circumſtances wherein they correſpond, they differ in others. Lead, for inſtance, is eaſily reduced to a calx; and tin more eaſily ſtill: but the calx of lead readily melts, and runs into a browniſh glaſs; whereas tin does not fuſe and vitrify without much difficulty. Tin and lead do readily mix and unite with each other by a gentle fire; but, if the heat be intenſe, there ariſes a colluctation between them; the effect of which is, that both fall into a calx; and that the lead becomes exceeding difficult, afterwards, to fuſe, and vitrify. Add, that tin is eaſy to be revivified; but lead, not without the utmoſt difficulty: nor is the reſtauration any thing compleat; or the new body in all reſpects like the old one.

 but

but the ſtrongeſt and hardeſt acids, boil'd in the ſame veſſels, make no ſolution at all.

*Without calcination.* Tin, freed, by calcination, of its ſulphur, diſſolves readily enough, in all acids; and is reducible thereby into vitriolic cryſtals, which afford a noble remedy againſt diſeaſes of the nervous kind.

Yet is it but little known and uſed in medicine; by reaſon of the difficulty of diſſolving it; for it is to be firſt thoroughly calcined e'er a ſolution be attempted. The calcination requires a continual fire for three days; after which the calx is diſſoluble in common vinegar. This is that excellent remedy of *Angelo Sala*, againſt the epilepſy and hyſteric affections; in which it is not a leſs certain cure, than the bark in agues, or opium in want of reſt.

*Its ſound.* The ſeventh *character* is to be very little ſonorous; leaſt of any metal, except lead; and yet, when mix'd with other ſounding bodies, to augment their ſound: as is evident from the ſhare it has in the compoſition of bell-metal.

Add, that tho' it be but little elaſtic in it ſelf; yet when mix'd with other elaſtic bodies, it wonderfully encreaſes their elaſticity*.

*Where tin is found.* Tin is principally found in *Cornwall* and *Devonſhire*, provinces of *England*, from whence all the reſt of *Europe* is ſupplied with this metal. 'Tis ſo much the peculiar produce of this country, that *Cambden* ſuppoſes it to have given the denomination *Britain* to the iſland. In the *Syrian* and *Chaldee* tin is call'd *bragmanac*, q. d. *Jupiter*'s kingdom; the primitive whereof is *Bratman* or *Britman*, whence our *Britain*.

*In what form.* Its glebe, or ore, is a heavy ſpongeous ſtone; reſembling a ſtone gnaw'd, or prey'd on by ſulphur, or a bone half calcined.

*How ſeparated and purified.* Theſe ſtones being broke and powder'd, undergo a lotion by water; by which means all the light earthy part is waſh'd away, and the tin left at the bottom.

The matter thus ſeparated, is next fuſed in a violent fire, by which means a deal of ſcoria is emitted, and the reſt left pure tin. Which, if by any further proceſs, it be purg'd of all its earthy, and fatty parts, approaches very near to the nature of ſilver †.

We

* A body, Mr. *Boyle* obſerves, by being aſſociated with another, may have new properties and uſes, and ſome of 'em quite different from what it had alone; *i. e.* two, or more materials, being conjoined, may be qualified into a third, by virtue of freſh properties thence accruing to the compoſition. As tin is flexible, and yields but a dead ſound, who would dream that one conſiderable uſe of it ſhould be to make a leſs yielding and better ſounding metal, more ſtrong and ſonorous? yet bell-metal is principally compos'd of tin and copper. *Uſeful. of Exper. Philoſ.*

† The ſtones from which tin is wrought, Dr. *Merret* tells us, are uſually found betwixt two walls of iron-colour'd rocks, of little or no affinity with the tin; in a vein or *lead*, as the workmen call it, betwixt 4 and 18 inches broad: tho' inſtead of ſtones they ſometimes alſo find it mix'd with a ſmall gravelly earth, generally of a red colour, but ſometimes white. From this earth, the tin is eaſily ſeparated by bare waſhing; which is call'd *pryan tin*, and is ſcarce half the value of the former.

In

### *Corollaries concerning the common nature and principles of Metals.*

WE have now gone thro' the first clafs of foffils, *viz. Metals*, in all its branches; and what we have here done, may ferve as a fpecimen in what manner phyfical things are to be defin'd, and explain'd: not by fuppofing any previous hypothefis, and deducing their nature therefrom; but by laying down their feveral apparent properties. From which we now proceed to draw fome corollaries, which may furnifh a general doctrine, or theory thereof.

## COROLL. I.

That which diftinguifhes metals from all other bodies, as well as from each other, is their *heavinefs*; for every metal is found to have its peculiar weight, which no art is able to imitate; and which depends, as *Helmont* and the chemifts exprefs it, on the *anatick* homogeneity of the parts. *Weight the effential character of a metal.*

Now, the later philofophers have proved, that all corporeal magnitude has juft fo much reality in it, as weight: and therefore, if you have found the heavinefs of any metal, you have at the fame time found its corporeity. Sir *If. Newton*, treating of gravity, and *Huygens* of the pendulum, fhew that weight and reality are correfpondent.

## COROLL. II.

Metals appear to be fimple; and yet are really compounds: their component principles, according to the antients, are *fulphur* and *mercury*; to *Metals, compound bodies.*

In the tin ore, is frequently found a hard glittering fulphurous fubftance, call'd *mundic*, or *maxy*, which is commonly fuppos'd to feed the metal; yet where the mundic abounds, they rarely find much tin. This mundic is to be carefully feparated; for if there be the leaft of it left, in melting the tin, it makes it brittle, and cruddy, and diminifhes much of its ductility.

There alfo occurs a fort of fpar, of a fhining whitifh fubftance, foft and fattifh at firft, but foon after growing fomewhat harder: it feldom grows, but only fticks to the metal. Some of the miners account this the mother, or nourifher of the metal. The beft ore is that in fparks, and next to this, that which has bright fpar in it.

The ore being dug, they break the greater ftones, and thus carry it to the ftamping or knocking mill, where it is pounded with large lifters headed with iron, 30, or 40 pound a-piece; and thus reduced into a fmall fand, to be wafh'd out by a ftream of water, difcharg'd into it from a cock, thro' a brafs grate holed very thick, into a *launder*, or trench dug in the floor; out of which the water efcapes, carrying with it the parts not metalline, which they call the *caufalty*, at bottom.

To clear away the *mundic*, they dry, or burn the ore, thus feparated, in a kiln, upon iron plates; keeping the matter conftantly ftirring, that all the mundic may by degrees get uppermoft, and fo be burnt away; which they difcover by the flames growing yellow, and the ftench diminifhing. Then they proceed to grind it again, very fine, in a *crazing* mill: after which they wafh it; then dry it a little; and at laft carry it, thus prepar'd, to the furnace, which they call a *blowing* houfe; and there melt and caft it.

When it runs out of the furnace, there fwims on it a *drofs* or fcum like that of iron; which being melted down with frefh ore, runs into metal.

The caufalty they throw in heaps upon banks, which, in fix or feven years, they fetch over again. *Philof. Tranfact.* N°. 69. *p.* 2096. and N° 138. *p.* 948.

which ſome of the moderns have added *ſalt*. But, 'tis certain, ſalt is no proper conſtituent part or ingredient of metals; but rather ſomething external adhering to 'em, and which makes no part of their metalline compoſition *.

*Their principles.* All metals then conſiſt of two kind of parts, or principles, *viz. mercury* as the baſis or matter; and *ſulphur* as the binder or cement: the firſt, the ſubſtratum, or metalline matter; the ſecond, that which renders it fix'd, and malleable.

*Mercury.* This *mercury*, it is to be noted, is the ſame with our quick-ſilver, only more defecate and clear of any of thoſe heterogeneous matters, wherewith the common quick-ſilver is always mix'd: as to the *ſulphur*, it is not the vulgar foſſil ſulphur, whereof we ſhall treat in its place; but a peculiar ſort of matter, ſpecifically denominated *ſulphur of metals*, and contended by ſome of *Sulphur.* our lateſt, and beſt chemiſts, particularly Monſ. *Homberg*, to be light or fire †. This being united with the mercury, fixes it; and according to the different degrees of its union, and coherence therewith, produces different metals.

This doctrine of the compoſition of metals, is confirm'd by an experiment of Mr. *Boyle*, who after having retain'd mercury a long time in a moderate fire, took a piece of gold out of it, which, it was apparent, was not in the mercury before it was expos'd to the fire.

Monſ. *Homberg* has an experiment to the ſame effect; from which he deduces that gold conſiſts of a ſulphurous or igneous part; and a heavy, mercurial part fix'd thereby ||: and that by only taking away the

* "In the analyſis of metals, we meet "with mercury, a ſulphurous matter, an "earthy matter, and in ſome a ſaline mat-"ter". *Homberg Mem. l'Acad. An.* 1702. but this is chiefly to be underſtood of the imperfect metals; or of perfect ones not in their utmoſt purity; tho' the burning glaſs, we have already obſerv'd, ſeparates a vitrifyable earth, even from the moſt perfect of all.

† This we ſhall have occaſion to ſpeak of more largely in the chapter *of fire*.

|| In an elegant memoir, *du ſouffre principe*, that ingenious and experienc'd author ſhews how a real malleable gold may be made of mercury, by only keeping it a long time expos'd to the fire, ſo as it may receive and retain a ſufficient quantity of the matter thereof, to fix its ſlippery, volatile globules together, and make 'em ſuſtain the fire, &c. In a ſecond memoir, *du mercure principe*, he teaches to deſtroy both the gold and mercury, by applying it in the focus of a large burning glaſs; by the vehement action whereof, the pores of the mercurial globules are ſo enlarg'd, and broke into each other, that unable, any longer to retain the fire lodg'd therein, it eſcapes; taking the greateſt part of the mercury along with it; and only leaving a little light terrene matter behind.

The better to conceive, how mercury, when become a metal, ſhould thus be deſtroy'd, by the penetration of the ſun's rays, which are the ſame matter of light, that by a former penetration had converted the ſame mercury into a perfect metal; he ſhews that a perfect metal is pure mercury whoſe globules have been gradually pierc'd on all ſides by the matter of light or fire; that the holes, or perforations made thereby, are all entirely fill'd with that matter; that theſe holes are ſo ſmall, that the light introduc'd within 'em, ſticks there by its natural gluten; that the extremes of the perforation of a mercurial globule being contiguous to the extremes of the like perforations of ſeveral other globules,

the sulphurous, or fiery part, the gold is reconverted into a running mercury *.

*Metals reducible into their original mercury.*

There are two ways of effecting this, *viz.* either by the revivifying salts of vegetables, or by mercury.

That by *mercury*, M. *Homberg* assures us, is very easy ; for that mercury, being purg'd of all heterogeneous matters, becomes a liquor, or menstruum that dissolves gold, by attracting, and melting the sulphur which fix'd the parts of the gold.

The like is done by those salts, which, from their effect, are denominated *revivifying*, *viz.* by their penetrating the metals, absorbing the fix'd parts, and, as it were, resuscitating the metals into their principles.

And hence all the books of the alchemists, are full of saline menstruums which act on gold in such manner as to fetch out its *soul*, *i. e.* our *sulphur* ; leaving the *body*, *i. e.* that *merc ury* of *metals*, behind 'em.

If it be ask'd why gold, if it only consist of the above mention'd principles, should be heavier than mercury ? the answer is, that the particles of fire or light, which Mr. *Boyle*, and Monf. *Homberg* demonstrate to be heavy, coming to insinuate themselves into the pores of the mercury, and there fixing ; increase its specific gravity. And no wonder : since the same is found to obtain even in calcin'd lead, as is known to all who have seen *minium* made.

globules, bind 'em together, by means of those parts of the matter of light found at such extremes of perforations ; and that by such means the whole mass of mercury becomes bound together. Now, notwithstanding this new union, the mercury and light still retain their nature, without any alteration ; so that if by any occasion the light can be disengag'd, it will return into the general mass of light, which possesses the whole space of the universe : but the intense fire convey'd by a burning concave does, no doubt, furnish such an occasion. The vehemence wherewith the reflected rays are thrown into the focus, is such as no material substance can withstand. The rays drive in continual streams thro' the globules of mercury, dissolve, and break 'em into pieces, &c.

The great quantity of light imbib'd by the mercury, in making gold, possessing, as it were, the whole surface of the globules, effaces their native whiteness, and tinges 'em with its own yellow ; whence the colour of gold : and hence also the great weight of gold ; the particles of light entering the substance of the mercury, and adding their own weight thereto, without augmenting the bulk. *Mem. de l'Acad. R. An.* 1709.

* Silver, according to the same author, differs from gold, in nothing but this, that the globules of its mercury are not so much penetrated, nor so thoroughly saturated with the sulphurous principle, or fire ; a less quantity of which being lodg'd in the pores of silver, than of gold, leaves it short in point of gravity, &c. and does not discolour it.

Accordingly, proceeding on this supposition, he actually found that he could produce gold, by introducing a large quantity of fire, or of the rays of light, into silver. And hence it appears, that gold should be longer in forming than silver ; and that all gold was first silver. *Memoir. de l'Acad. An.* 1709.

## COROLL. III.

*What hinders common mercury from being gold.* All metals muſt firſt be mercury e'er they be gold; and the thing ſuperadded to common mercury, whereby it is prevented from becoming gold, is a ſharp, volatile body; which when heated becomes corroſive, and emits fumes; which are the properties of the *foſſil ſulphur* †.

This doctrine has been ſufficiently laugh'd at, and exploded by many philoſophers; but 'tis from their ignorance of the nature of metals.

In effect, what is here advanc'd, is the reſult of a world of experiments; nor does it appear, in any reſpect, inconſiſtent with reaſon: it muſt be admitted, then, as inconteſtable, that mercury is the matter of all metals; that as this is more or leſs pure, the metal is more or leſs ponderous; that there is no proof of any reality ſo clear and ſtrong, as what is fetch'd from weight; and that the ſpecific nature of a metal is known thereby. In effect, 'tis our opinion, that if any metal, or other body could be found, that only differ'd from gold in its wanting weight; it were impoſſible, while under that defect, ever to make gold of it; and, on the contrary, if a body could be had as heavy as gold; all the other properties of that precious metal, *v. g.* colour, fixity, ductility, *&c.* might eaſily be added.

*Silver with all the characters of gold except weight.* To ſay no more, I can ſhew ſilver that has moſt of the criterions of gold, excepting weight; being abſolutely fix'd in the fire, and almoſt fix'd in antimony; and I can give it the colour of gold: and yet 'tis ſtill, and will be, ſilver. But ſhew me ſilver as heavy as gold, and I will undertake to convert it into gold.

Hence the more knowing among the alchemiſts maintain, that "if you "would convert, *e. g.* a piece of tin into gold, you muſt firſt carry it thro' "all the intermediate weights of the other metals, *i. e.* it muſt firſt be the "weight of iron, then of copper, then ſilver, then mercury, and at laſt "gold.

*Dogmata of the alchemiſts.* They add, "that the primary matter of gold is mercury, which, ſay "they, is gold at heart; as coming neareſt to gold in the point of ſpecific "gravity: only there is a corroſive body, or ſulphur, adhering to it, which "if it were ſeparated, you would have ſilver; or if it were only inverted, "gold. On this principle, whoever would make gold out of any other fo-"reign matter, muſt remember, that the more his matter differs from mer-"cury in weight, *&c.* the leſs gold it will make; that if quickſilver could "be reduced to the ſimplicity, and purity of gold, it would be gold; that the "matter which coagulates, or fixes this mercury into gold, *&c.* is a very "ſubtile ſulphur; and that as we ſee, that quick-ſilver being held over the "fumes of lead, is readily fix'd, it appears that a very little fixing matter ſuf-"fices; that if mercury, coagulated by ſulphur, have any impurities therein, "it becomes lighter, and leſs perfect than quick-ſilver it ſelf; that in the "purification of mercury, to its higheſt degree, conſiſts the making of gold;

† See the chapter of *ſulphurs*.

"that

"that nature, in ſome caſes, is able to atchieve this of herſelf; that in "other caſes, where ſhe is unable to do this, there ariſes a leſs noble me-"tal; and that if the ſulphur be not ſtrictly homogeneous, there will ariſe a "ſtill more imperfect metal." Such, now, is that abſtruſe, formidable doctrine of the alchemiſts; ſo undeſervedly exclaimed againſt by the other philoſophers.

## COROLL. IV.

Metals, therefore, appear tranſmutable into one another. For if mercury be the common matter of all metals; and if all the difference lie in the fixing matter, which, as 'tis more or leſs ſubtile and pure, conſtitutes this or that metal; 'tis no way improbable they ſhould be converted, by a purer fixing ſulphur's taking place of a corroſive one, into a more perfect metal. *Tranſmutation of metals not impoſſible.*

## COROLL. V.

The pureſt metals reſult of the pureſt and moſt defecate mercury, join'd with the ſubtileſt ſulphur; hence mercury of gold is heavier than common mercury, which has always ſome impure part that is lighter than gold: and could that be taken away, and the fixing ſpirit be added, it would become gold. *Compoſition of the perfect metals.*

## COROLL. VI.

The imperfect metals conſiſt of impure mercury, and imperfect ſulphur; each containing ſome other variable heterogeneous matter in it: thus tin expoſed to the fire, emits a fume which whitens copper; after which, it exhales a pure ſulphur. *Of the imperfect.*

The reality of ſuch a third matter is evinc'd hence, that all theſe baſer metals are reſolvable, not only into mercury, and ſulphur, but alſo into ſcoria, or ſordes, which are lighter and more earthy than either of the other, and accordingly ſwim therein.

If this matter can either be changed, or be perfectly purg'd away, any one metal were convertible into any other; the moſt impure, into the pureſt. Thus, *Centivoglio: Nature ſublimes mercury in the earth, by heat; which ſublimation is repeated again and again, till every thing impure and heterogeneous be carried away, and what is pure left at the bottom. When what is thus left, is quite pure, it is gold.* Agreeable to this, is that of Monſ. *Homberg: Separate the pure, from the impure, over and over; and you will obtain what you deſire. This is juſt the caſe of nature: if ſhe can carry the ſeparation to its pitch, gold is produc'd; otherwiſe, ſome baſer metal.*

This fixing ſulphur is held by ſome alchemiſts an univerſal medicine in all caſes where the innate warmth is wanting, and the native force decay'd: but in acute caſes, it is quite the contrary, and certainly deſtroys. Thus,

in

in *Centivoglio*, an alchemiſt enquires of ſulphur, which appear'd to him in his ſleep ; *Is the univerſal medicine in thee ? Yes*, replies *ſulphur* ; *provided you apply me where the vital heat and force of fire is wanting : but where there is too much of that heat and force in the body, I deſtroy.* Hence *Helmont* was induc'd to believe ſulphur to be the grand elixir ; but *Centivoglio*, and *Van Suchten*, a diſciple of *Paracelſus*, more diſcreetly limit the uſe of this univerſal medicine, to chronical caſes, and particularly hydropical and lunatic ones.

Thus much for *metals* : and by this time, what with our own experiments, and what with the ſure obſervations of the beſt, and moſt intelligent authors, we have got a pretty adequate notion thereof.

We have added what relates to the art of *tranſmuting* ; that ſuch as have the curioſity to make any experiments in this kind, may have ſome laws, marks, or aims, whereby they may ſecurely direct themſelves ; and that ſuch as might be in danger of being impoſed on by fraudulent alchemiſts, may be furniſhed with means to diſcover the deceit. The weight, once more, is the immutable judge ; and, in all caſes of doubt, appeal to the balance.

This doctrine of tranſmutation, may be of eſpecial ſervice to the novices in chemiſtry ; who, by I know not what fatality, have an almoſt univerſal itch after the philoſopher's ſtone, and the making of gold. Inſtances of vain people, reduced from plentiful fortunes to the loweſt beggary, by their own conceits, or the empty pretenſions of deſigning alchemiſts, fall under moſt peoples obſervation.

*Second*

# Second Claſs of Foſſils.

## SALTS.

AFter metals, the next bodies in order of ſimplicity, are *ſalts*; the definition whereof is as follows: Salt.

*Salt is a foſſil body, fuſible by fire, and congelable again, in the cold, into brittle glebes or cryſtals; ſoluble withal in water, ſo as to diſappear therein, never malleable; and having ſomething in it which to the organ of taſte affords a ſenſation of acrimony or ſharpneſs.* Defined.

Such is the preciſe idea of a *ſalt*; which agrees to all ſalts whatever; and by which a ſalt is diſtinguiſhed from all other foſſil, vegetable, and mineral bodies.

The properties peculiar to any ſpecies of ſalts, are not taken into this definition: thus, we don't ſay, *that it excites thirſt*, or the like; ſince the ſalt in ſugar is ſweet, and has no ſuch effect.

*Foſſil-ſalts* are of two kinds; *native* or *ſimple*, and *compound*. We have here only to do with the *native* ones: which are,

1°, *Sea-ſalt*, *ſal marinus*, thus called becauſe extracted from ſea-water: it is the moſt univerſal of the whole tribe; being found in every part of the ocean, and in every gulph, &c. communicating therewith: witneſs the *ſaline* taſte in all ſea-water; but in lakes, or other ſtagnant waters, it is ſcarce found at all *. Common ſalt.

'Tis this ſaltneſs of the ocean that prevents its growing fetid, and putrefying by the heat of the ſun; and yet, notwithſtanding all its ſaltneſs, the freſheſt fiſhes live, and grow therein. It is found in greateſt abundance, where the ſun's heat is the moſt intenſe; and the leaſt in the coldeſt regions. This

* For *ſea-ſalt*, the greateſt, and beſt part, is made along the coaſts of *France*. There are two kinds of it; the one requiring the ſun's rays to bring it to a conſiſtence, call'd, from its brown colour, *bay-ſalt*; the other receiving its conſiſtence from the heat of a fire, called *white-ſalt*: either the one or the other method is practiſed, according to the diſpoſition of the coaſts where 'tis made. If they riſe in downs, or banks of ſands, the ſalt is made by fire, in copper, or leaden veſſels: if the bottom be clayey, the ſalt is cryſtallized wholly by the action of the ſun. The method of proceeding in each, is as follows:

1°, For *bay-ſalt*. Low, marſhy grounds, diſpoſed by nature for the reception of the ſea-waters when the tide ſwells, and provided with banks and ſluices to retain the ſame; they call a *ſalt-marſh*. Theſe ſalt-marſhes, the bottoms whereof they ram with great care, are divided into ſquare pits or baſons, ſeparated by little dikes; and into theſe baſons, when the ſeaſon is at hand, they let in the ſea-water. The ſalt-ſeaſon is from the middle of *May* to the end of *Auguſt*. The water is admitted to the height of about ſix inches; after having firſt let it reſt, and warm two or three days in huge reſervoirs, without the works, that it may come

This ſea-water, being firſt percolated thro' a *Manica Hippocratis*, or ſtraining-bag, is then boil'd, ſcum'd, and evaporated to the conſiſtence of a brine or pickle; (which is proved by a new-laid egg's ſwimming therein,) in which ſtate being left to ſettle, the ſalt ſinks to the bottom in cryſtals.

*Rock-ſalt.* 2°, *Sal gemmæ*, popularly call'd *rock-ſalt*, is dug out of mountains, and cloven or ſlit into glebes or lumps.

The fineſt in all *Europe* is in a mountain of *Catalonia*, not far from the city *Barcelona*: but there is ſcarce any part of the earth without it; no part, at leaſt, that has any mines at all. In *Poland*, *Ruſſia*, &c. there are ſeveral whole mountains thereof *.

Thus

come in luke-warm. The water admitted, the ſluices are ſhut, and the reſt of the work left to wind and ſun.

The ſurface of the water being ſtruck, and agitated with the direct rays of that luminary; thickens, at firſt imperceptibly; and becomes at length cover'd over with a ſlight cruſt; which, continuing to harden, is wholly converted into ſalt. The water in this condition is ſo hot, that the hand can't be put in without ſcalding. When the ſalt has receiv'd its full coction, they break the cruſt with a pole; upon which it ſinks to the bottom: whence, being dragg'd out again, they leave it in heaps about the pit, to compleat its drying; covering it over with ſtraw, or ruſhes, to ſecure it from the rain.

Eight, ten, or at moſt fifteen days, having thus compleated the cryſtallization, they open the ſluices, when the tide riſes, for a freſh ſtock; and thus, alternately, while the ſeaſon holds.

2°, *White ſea-ſalt.* On the flat ſhores of *Normandy*, they gather a muddy ſand, which the riſing tide has impregnated with its waters for ſeven or eight days. This ſand being removed into pits for the purpoſe, diſcharges itſelf, by degrees, of all its water; which filtrates thro' ſome ſtraw, wherewith the bottom of the pit is fill'd; and trickles into veſſels ſet on purpoſe to receive it.

This water they lade out into leaden boilers, with furnaces under them. As ſoon as it begins to boil, they take off the skin, which riſes in great quantity; and in proportion, as it diminiſhes, throw in freſh water, which they continue to skim, as before. When it thickens, they keep it continually ſtirring; and when the grain is form'd, take it off the fire.

This done, it is put in large oſier-baskets; where it ſtands ſome time to purify, and drain itſelf of certain humidities that remain'd: when dry, it is laid on heaps, and thence carried to the magazines.

*Note*, They have alſo a method of refining *bay-ſalt* into *white-ſalt*, by boiling it in large flat caldrons; which not only takes away a deal of its acrimony, and alters its colour, but is alſo found to increaſe the quantity.

* This ſalt appears to have been entirely unknown to the antients. *Pliny*, indeed, gives us ſome curious things about ſalts, which we ſhould have been glad to have tranſcribed hither, could we believe them as true as they are pretty. Inſtead hereof, we ſhall content ourſelves with what well-warranted relations we could get of thoſe celebrated ſalt-mines of *Wilizca* in *Poland*; from whence the reſt of *Europe* is ſupply'd in great meaſure with this ſalt.

The mines in the village *Wilſce*, five leagues from *Cracow*, were firſt diſcovered in 1251; their depth, and capacity, are ſurprizing: within them is found a kind of ſubterraneous republic, which has its polity, laws, families, and even high-ways, and common carriers; horſes, and other cattle being kept here to draw the ſalt to the mouth of the quarry, where it is taken up by engines. Theſe horſes, when once they are down, never ſee the light more; but the men take frequent occaſions of breathing the village-air. When a traveller is arrived at the bottom of the ſtrange abyſs, where ſo many people are interr'd alive, and where ſo many are even

This ſalt being diſſolved in water well-ſcum'd, and ſet in a cool place, ſhoots into cubical or priſmatical cryſtals, very ſmooth, polite, *&c.*

Theſe two ſalts ſcarce differ in any thing but the place they are found in; unleſs, perhaps, in the degree of purity, and dryneſs; in which the latter exceeds. They have both the ſame effects on gold, which is not diſſolvable by any other ſalt in nature, but theſe two. They have the ſame effects, too, in the making of ſpirit of ſalt, in fertilizing barren grounds, in ſeaſoning, pickling, and other culinary uſes; and their taſte is the ſame.

In effect, there is no room to doubt but that they are really one and the ſame ſalt; and that ſea-ſalt had its firſt riſe from *ſal gemmæ* diſſolved at the time of the flood; and ſince that, by earthquakes, inundations, *&c.* which have laid parts of the earth under water.

Theſe two are called *perfect ſalts*, and are of all others the moſt fixed, and immutable both in the fire and the human body: ſalt-petre, even the moſt refined, periſhes, or is quite loſt when ſwallowed down; and ſal-ammoniac, borax, *&c.* ſhew no ſigns of themſelves in the urine: but ſea-ſalt, *&c.* may be always drawn from it; ſo that it muſt be allow'd an exceedingly ſimple body *.



even born, and have never ſtirr'd out; he is ſurprized with a long ſeries of lofty vaults ſuſtain'd by huge pilaſters cut with the chiſſel; and which, being themſelves rock-ſalt, appear, by the light of flambeaux, which are inceſſantly burning, as ſo many cryſtals, or gems of various colours, caſting a luſtre which the eye has much ado to bear.

The rocks of ſalt are hewn in form of huge cylinders; the workmen uſing hammers, and chiſſels, much as in our ſtone-quarries. As ſoon as the maſſive pieces are got out of the quarry; they break them into fragments fit to be thrown into the mill, where they are ground into a coarſe farina, or flower.

Here are two kinds of *ſal gemmæ*, the one harder, and more tranſparent, and which appears to be the more perfectly cryſtallized. This is the proper *ſal gemmæ*, and is frequently cut like cryſtal, and form'd into toys, chaplets, little vaſes, *&c.* The other is leſs compact, and only fit for kitchen-uſes. One of the chief wonders of the place is, that thro' theſe mountains of ſalt, and along the very middle of the mine, there runs a rivulet of freſh water, ſufficient to ſupply the inhabitants.

In the ſalt-mines of the *Upper-Hungary*, and the mountains of *Cardonna* in *Catalonia*, the ſalt-ſtone is found of various colours, bay, white, red, blue, green, brillant, *&c.*

* To the ſame ſpecies of ſalts, muſt, likewiſe, be refer'd that commonly made, and uſed in our own country; *viz.* the ſalt drawn from brackiſh ſprings; which, no doubt, either ariſes from the ſalt-water of the ſea receiv'd up thro' certain ſubterraneous cavities, and depoſited here; or from ſome mineral or gem ſalt, lodg'd in the *ſtrata* of ſome of the mountains not far off, waſh'd down by ſome rivulet or track of water, and gather'd here. The way of preparing it, is thus:

Near the ſpring is built a *ſaltern* or boiling-houſe, furniſhed with ſeveral huge, flat pans, with each its grate, and furnace. Into theſe the brine is convey'd by pipes; the fire kindled; and in two hours time the liquor begins to be ready to granulate, which is known by a thin ſkin riſing at the top, which they ſkim off into brine-tubs. The ſand, which the water yields pretty plentifully, is by the violence of the boiling caſt to the ſides, and corners of the boiler; where they lade it out into veſſels for that purpoſe. Both this

Salt-petre.

3°, Is *ſalt-petre*, called alſo *nitre* *, and *ſal nitri*, whoſe characters are, 1°, That its cryſtals are of a priſmatic figure, with hexagonal baſes. 2°, That it diſſolves by fire more readily than any other ſalt; but with ſome difficulty by water or moiſt air. 3°, That it is the coldeſt of all ſalts, and affects the tongue much like ice; having a ſaltiſh ſavour withal. 4°, That it is the baſis of *Aqua fortis*, and diſſolves ſilver.

As to the origin of ſalt-petre, 'tis controverted among naturaliſts, whether it be a foſſil or an animal ſalt; ſome holding it producible from the

ſand, and the ſcum, contain ſalt, which they procure by a future operation.

The ſand being removed, they ſhut up the vent-holes, and door, and let the fire go out; and in twelve hours time, the ſalt is precipitated to the bottom; where it grows hard; a liquor, call'd the *bittern*, remaining a-top; which being boil'd over again, yields more ſalt.

To make the ſalt precipitate more readily, they frequently uſe beef-ſuet, and wine-lees, of each an equal quantity; melting them together, and putting an ounce of the mixture on the end of the ſlice, and turning it round in the liquor, till all be ſpent: then, after two hours at moſt, opening the vent-holes, &c. and quickening the fire, they lade away the liquor; and find the ſalt lying at the bottom.

Laſtly, taking it out, they put it into cribs or ſepels like hay-racks; where, after eight hours draining, it is found a hard, granulated ſalt; yet it continues dripping a fortnight longer; and, unleſs it be frequently ſtirr'd, becomes rocky.

* As to that of the antients, 'tis diſputed among naturaliſts, whether their *nitre*, *natrum*, were the ſame with our *ſalt-petre*. The account *Serapion* gives us of nitre, ſhould make them very different; for he ſays it was dug out of mines like thoſe of common ſalt. He adds, that their nitre was of four kinds, denominated from the countries whence it came; *viz. Armenian*, *Roman*, *African*, (call'd *Aphronitre*, and by *Avicenna*, *Baurach*) and *Egyptian*, which being the moſt famous, gave name to all the reſt; itſelf being denominated from *Nitria*, a province in *Egypt*, where it was found in great abundance. He aſſures us, too, that their nitre was of divers colours, *viz.* white, red, and livid; that ſome was ſpungeous, others more compact, others tranſparent, others ſcaly, &c.

The learned *Schelhammer*, in an expreſs treatiſe, *De nitro, tum veterum tum noſtro*, ſets the thing in a very different light: the antients, he obſerves, diſtinguiſhed *νιτρον*, *nitre*; *αφρονιτρον*, *Aphronitre*; and *αφρος νιτρȣ*, *ſpuma nitri*, or *ſcum of nitre.* He adds, that *Agricola*, and other authors, are miſtaken when they ſay that there were antiently mines in *Lydia*, *Magneſia*, *Caria*, &c. out of which nitre was dug like ſtones out of a quarry. The nitre uſed by the antients was brought from ſeveral countries mentioned by *Pliny*, lib. xxxi. c. 10. A lake in *Macedonia*, whoſe waters were nitrous, furniſhed the greateſt quantity, and the beſt; it was call'd *calluſtricum*, from a neighbouring cape in the gulph of *Theſſalonica*; and was form'd like a cruſt on the ſurface of the water, during the dog-days. On the other hand, the waters of the lake *Aſcanius* in *Bithynia*, and thoſe of certain ſprings near *Chalcis*, were ſweet, and potable toward the ſurface, yet nitrous at bottom. There was alſo nitre gathered on the ground near *Philippi* in *Thrace*; but it was little, and of no great value. The valleys of *Media* alſo furniſhed ſome.

The reader, who is curious to enter more minutely into this controverſy, may conſult the *Acta Erudit. Lipſ. Ann.* 1707. p. 361. *Ann.* 1709. p. 318. *Ann.* 1711. p. 214. The *Ephemer. Curioſ. Nat. Dec.* 1. *Ann.* 1. p. 290 & 403. *Ann.* 4 & 5. p. 285. *Ann.* 6 & 7. p. 170. *Ann.* 8. p. 270. *Ann.* 9 & 10. p. 270. *Dec.* 2. *Ann.* 3. p. 87. *Ann.* 4. p. 21. *Ann.* 7. p. 306. *Ann.* 9. p. 88, &c.

mere excrements of animals *. But this is not so just, as to say that it is produced from those excrements intermixed with the salts of vegetables, &c. which seems to constitute it rather an hermaphrodite, or salt of a middle kind, between fossil and animal †.

We have four sorts of salt-petre; two *native* or *fossil*; and two *factitious*.

The *first native* salt-petre is brought from the *Levant*; where it is dug up from under ground, in mountains, &c. in form of a variously colour'd mineral glebe ‖.

The *second*, called *Natron*, or the *Egyptian* nitre, is of a more cineritious colour, and a bitterer taste; approaching nearer to the nature of a *sal-ammoniac*.

It is not produced from the plant *kali*, or salt-wort, as some have imagined; but from a huge lake in *Egypt*, on whose banks the camels, and other animals, lay their excrements; which by the inundations of the lake being drawn into the water, are supposed to afford the matter of this salt.

The water of this lake being scorched, and evaporated by the heat of the sun, gathers a pellicle or scum, which being dissolved, and crystallized, yields the salt **.

The

* M. *Homberg* observes, that all the salt-petre we now have, is either drawn from earths moisten'd, and manured with the excrements of animals; or from old walls, and the plaister of ruin'd buildings impregnated with the excrementitious *effluvia* of the animals that inhabited them. *Mem. de l'Academie.*

† Indeed, salt-petre may be made many ways. M. *Lemery* made it both of animal, and vegetable matters. *Ludovicus* observes, that the art of making a real nitre of the essential salts of certain plants join'd with a fixed salt, has been known long ago; oil of tartar *per deliquium*, pour'd on spirit of nitre, evaporated to a cuticle, and left to crystallize, does the business. *Nouv. Cours de Chymie.*

‖ This species of salt-petre, call'd *mineral salt-petre*, is found in several places in the kingdom of *Persia*, &c. particularly about *Agra*; in villages antiently populous, but now desert. 'Tis also found in some places about the river *Wolga*.

The glebe or earth from which it is procured, is of three different kinds; black, yellow, and white: The method of procuring, is thus; two flat pits are dug, one of which they fill up with the mineral earth; turning water upon it for some time, and then treading it with their feet into the consistence of a pap; and letting it stand two or three days for the water to imbibe, and extract all the salt. They then shift the water into another pit, where standing some time, it shoots, and crystallizes into salt-petre. To purify it, they boil it once or twice, as they would have it more or less pure.

** This salt-petre is furnish'd by the waters of a dead lake in the district of *Terrana* in *Egypt*, call'd the *nitrian waters*, exalted and concocted by the heat of the sun, much after the manner of our bay-salt. This is the *natrum* or *anatrum* of the antients, which our druggists call *natron*.

Dr. *Huntingdon*, who was on the spot, observes that *natron* is commonly supposed to rise from the bottom of the lake, where, by the sun's heat, it is condensed, and harden'd into the form we see it: but his opinion is, that it is rather separated by the sun from the water. *Philos. Transact.* Nº

This salt agrees with our salt-petre in some properties, *viz.* in the pyramidal form of its crystals, &c. but differs from it in others, *viz.* its lixivious smell, fermenting with acids, &c. Dr. *Leigh* takes it to come nearer to the nature of a *sal-am-*

The *first* species of *factitious* salt-petre arises from a liquid matter or juice exuding out of old walls, and gathering into little white *flocculi*; which, by being pounded, become salt-petre.

This matter proceeds primarily from the calx or lime of the walls; tho' it is found, that if the stones themselves be boil'd in water, and the water filtred and inspissated, salt-petre will be obtain'd.

The *second* is procured from the *fæces* ††, and urine of animals: nay, all the very fleshy parts thereof, when putrified, afford this salt.

Sal ammoniac. The 4°, is the antient *sal-ammoniac*, or *sal Cyrenaic*, described by *Pliny*, and *Dioscorides*.

Its generation was in the earth, or rather, the sands, in those large inns, or *Caravansera's*, where the companies of travellers, or pilgrims, flocking from all parts to the temple of *Jupiter Ammon*, used to lodge. The method of conveyance in those parts being on camels; and these beasts, when in *Cyrene*, the province wherein that celebrated temple stood, urining in the stables, or, say some, in the parched sands; of their urine, which is found remarkably strong, was generated a sort of salt, denominated, sometimes from the temple, *Ammoniac*; and sometimes, from the region, *Cyrenaic*.

This salt being now no longer found in those places, some authors suspect there never was any such thing; and that the antient, as well as the modern *sal-ammoniac*, was factitious.

But we are inclined to think there might be a native salt of this kind; and the rather, as the salt belched out in large streams, or rivulets, from mount *Ætna*, is of the same nature; and that the ordinary spuma or froth emitted out of that mountain, affords a pure salt, which answers to most of the properties of the *sal-ammoniac*.

The true reason why this salt is no longer found in its former place, is, that the fane of the antient idol is now out of date; and that there are no oracles to be consulted there.

Its characters are, 1°, That it cools water. 2°, That it turns *Aqua fortis* into *Aqua regia*, and dissolves gold. 3°, That it remains fixed in a gentle fire, but sublimes by a large one. 4°, That the taste it affords, is quicker than that of salt, and resembles that of urine.

*Modern* sal ammoniac. The 5th salt, is the modern *sal ammoniac*, which some pretend to be native or fossil, and to trickle out of the ground in *Campania*, and other parts of *Italy*; as also about mount *Ætna*, in *Sicily*, in form of a liquor, which

*ammoniac*: which opinion is confirm'd by Dr. *Lister*, from a conjecture, that most of the salt-water of the lakes of *Egypt* must have passed thro' the bodies of those vast animals wherewith they are inhabited; as crocodiles, hippopotami: and consequently must have been render'd urinous: which is the character of *sal-ammoniac*.

†† This sort is chiefly made in *France*; particularly in the arsenal at *Paris*, where there is a corporation of salt-petre-makers appointed for the purpose. The materials are chiefly collected from old buildings, ruins, plaister, dove-houses, stables, privies, &c. The process is as follows:

They take, for instance, some old plaister, and put it in troughs, or vats; here they beat, and break it, and pour on it a lye made of new wood-ashes. This they repeat ten or twelve times, till it be saturated

which when filtrated, and inſpiſſated, becomes *ſal-ammoniac*. But 'tis certain, all the modern *ſal ammoniac* is compound, and factitious; and conſiſts of a foſſil, vegetable, and animal ſalt combined together *.

The 6[th] *ſalt* is *borax*, which is a native, foſſil ſalt, of a very extraordinary kind; of whoſe origin we have no well-warranted, and authentic account †. **Borax.**

It is very fuſible by fire, and in cold coagulates again, and ſhoots into glebes of a priſmatic figure. It is of a ſweetiſh taſte, promotes the fuſion of metals by fire; and when ſprinkled over them, ſerves to cement or ſolder them together.

It is principally uſed by goldſmiths, and other artificers to ſolder gold with other metals; in order to which, they apply a little borax powder on the gold, and melt it by a lamp; whence it is alſo called *Chryſocolla*, q. d. glue of gold.

The 7[th] *ſalt* is *alum*, which, tho' no pure, ſimple, native ſalt, yet has all the properties thereof; being diſſolvible in water, acids, *&c.* **Alum.**

Alum is of divers kinds, *red*, *roman*, *citron*, *ſaccharine*, and *plumeſe*; tho' the laſt is not properly alum, but a ſort of foſſil ſalt, which remains

rated enough to ſuſtain an egg: then they pour it into freſh veſſels; where, in cooling, it ſhoots into little greyiſh cryſtals, intermixed with ſea-ſalt. This done, they diſſolve it again in a lye, wherein the ſea-ſalt cryſtallizes firſt; and thus affords an opportunity of ſeparating it from the ſalt-petre. They proceed to diſſolve, and cryſtallize it again and again; skimming off the remains of the lye each time. When the ſalt is left pure, they melt it over a gentle fire; and thus pour it into veſſels to keep.

* There is ſcarce any drug more common than *ſal-ammoniac*; and yet we neither know whence it comes, nor how 'tis made. All that is certain, is, that it is brought from the *Levant*. The chemiſts all allow it a volatile, urinous ſalt, penetrated by an acid; and have divers ways of making the like: the common way is by putting one part of common ſalt to five of urine; to which ſome add half the quantity of ſoot. The whole being put in a veſſel, they raiſe from it by ſublimation a whitiſh, farinacious, friable ſubſtance; which is what they call *ſal-ammoniac*. But M. *Lemery* ſhews, that what is imported to us from abroad, muſt be made after a different manner. He even concludes, that it is made, as our common ſalt is, by mere lotion, and evaporation.

† *Pliny* ſpeaks of borax at large, in his *Nat. Hiſtory*, lib. xxxiii. c. 5. but his account is not perfectly conſiſtent with modern experience. He divides borax into native, and factitious: The native, according to him, is a kind of muddy juice, running in gold, ſilver, and copper, and even lead-mines; which being congeal'd, and harden'd by the winter's cold, arrives at the conſiſtence of a pumice. As to the artificial, he ſays, it is made by pouring water into the vein of a mine all the winter long, till *June*; and then leaving it to dry, and harden for three months: ſo that borax, according to this naturaliſt, ſhould be no more than the mineral corrupted. He adds, that the borax becomes yellow, white, green, or black, according to the mine it is found in.

The moderns, likewiſe, admit of a native, and an artificial borax: The native is a mineral ſalt, not unlike *ſal gemmæ*, dug out of the earth in divers parts, particularly in *Perſia*. It is alſo found at the bottom of a torrent, running from the mountains of *Purbeth*, near the confines of *White Tartary*.

The factitious is only the native purified, and refined, by diſſolving it in water, filtrating and cryſtallizing.

fixed

fixed in the fire. The saccharine again is artificial; and therefore has no place among native alums *.

Alum dissolves in water; and what remains undissolved, at bottom, is a sort of calx, which dissolves readily enough in oil, or spirit of vitriol. And hence, there arises some doubt whether alum, as it leaves an earth or *caput mortuum* behind it, does properly belong to the class of salts.

*Vague universal acid.*

The 8th and *last* is a certain *vague-salt* or *acid*, diffused in all parts of the earth; which, when alone, is volatile; but when it has a body or subject to adhere to, becomes fixed.

The idea of this salt we are at a loss how to convey, otherwise than by its effects; it seems to come nearest the nature of spirit of sulphur *per campanam*; and is discovered in all sulphur, in all vitriol, in all alum, in all nitre, in all fossil coals, *&c.* This same acid is that pernicious fume or damp, found in mines, and cellars; the same is that smoke which flies from bituminous turf, *&c.*

This we call the *saline acid* †, and look on it as a vague, indeterminate principle, distributed thro' every part of the globe, both inside, and out. 'Tis this *acid* that dissolves iron, and copper in hot baths; this, that meeting with fossil or rock-oil, coagulates, and converts it into *sulphur*: this that, being received into the earthy part of alum, or the *lapis calcarius*, converts it into alum: this, in fine, that, insinuating into the substance of iron, produces green vitriol; or into that of copper, blue vitriol, ‖ *&c.*

*Ele-*

* *England*, *Italy*, and *Flanders*, are the countries where alum is principally produced. The *English* alum is made from a blueish, mineral stone, frequent in the hills in *Yorkshire*, and *Lancashire*. This stone they calcine on a hearth or kiln; then steep it successively in several pits of water: then boil it for about twenty-four hours: Lastly, letting it stand for about two hours; the impurities subside, and leave a pure liquor; which, removed into a Cooler, and some urine added to it, begins, in three or four days, to gather into a mass: which being taken out, wash'd, and melted over again, is fit for use.

In the alum-works at *Civita Vecchia*, the process, as described by M. *Geoffroy*, is somewhat different. The stone, which is of a ruddy hue, being calcined, they boil, and dissolve the calx in water; which imbibing the salt, *i. e.* the alum, separates it from the useless earth. Lastly, leaving the water thus impregnated with salt, to stand for some days, it crystallizes of itself, like tartar about a But, and makes what they call *rock-alum*.

At *Solfatara*, near *Puzzuoli*, is a considerable oval plain, the soil whereof is wholly saline; and so hot, that the hand cannot long bear it. From the surface hereof, in summer-time, there arises a sort of flower or saltish dust; which being swept up, and cast into pits of water at the bottom of the plain, the heat of the ground, without any other fire, evaporates the water, and leaves an alum behind.

† This coincides with the *elementary* salt, or saline *principle*, the basis of all fossil salts. See it further consider'd among the other elements, under the article *Operations*.

‖ One of the principles into which sulphur is, by analysis, reducible, is an acid salt, which Sir *I. Newton* observes, "is "no other than the oil of sulphur *per* "*campanam*; and which abounding much "in the bowels of the earth, and particularly in marcassites, unites itself to "the

## *Elements or common principles of salts.*

OF *fossil salts*, some are *simple*, i.e. not reducible into any principles or component parts; such are *salt-petre*, and *borax*.

The rest are all resoluble into an acid spirit, and an insipid earth *. Thus, *e. gr.* if you take a quantity of sea-salt, and lay it open to the air in a shallow vessel of *Muscovy* glass; all that does not liquify, is earth: If it be in a place secure from dust, the salt thus liquified becomes brine; which being dried, and exposed again to the air, and this repeated over and over, the whole acid spirit will at length be evaporated, and nothing left behind, but the insipid earth, which readily absorbs any fresh acids, *&c.* poured on it, and re-commences salt †. Salt, therefore, contains a little share of earth to fix and retain its volatile acid ||.

" the other ingredients of the marcassite; " which are bitumen, iron, and earth; " and with them compounds alum, vi- " triol, and sulphur: with the earth a- " lone it compounds alum; with the " earth and metal, vitriol; and with the " earth, and bitumen, sulphur. *Optic.*

* " When metals corroded with a little " acid, turn into rust, which is an earth " tasteless, and indissoluble in water; and " this earth imbibed with more acid, be- " comes a metallic salt: and when some " stones, as spar of lead dissolved in pro- " per menstruums, become salts: Do not " these things shew, that salts are dry " earth, and watery acid, united by at- " traction; and that the earth will not " become a salt, without so much acid " as makes it dissoluble in water." *Newton. Optic.* p. 361.

† Yet M. *Homberg* insists, that there is always a little fixed salt remaining with the earth. *Mem. de l'Acad.* 1702.

|| Fossil salts left to shoot or crystallize, assume certain figures, which are usually attributed to them as their proper figures; tho' sometimes supposed to be the figures of the acids of those same salts. These figures are, in sea-salt, cubes; in sal-gem, parallelepipeds; in salt-petre, a sort of needle form; in alum, triangles, with the points blunted; in borax, flatted ovals; in sal-ammoniac, branchy needles, *&c.* Yet, upon examining the configuration of these salts, it will appear, that such figures do by no means belong either to the salts, or the acids, procurable from them; but rather to the alcalies whereby they are dissolved, and which serve them as bases. And hence, the same acid assumes different figures, according to the different alcalies it is saturated withal, e'er it crystallize. Thus, spirit of nitre, after dissolving copper, shoots into hexagons; after iron, into irregular squares; after silver, into triangular, dented plates, *&c.* *Homberg. Mem. de l'Acad. R. An.* 1702.

# *Third Class of Fossils.*

## STONES.

*Stones defin'd.* THe next bodies, in order of simplicity, are *stones.* Now, *A stone is a fossil body, twice as heavy as water; friable, and therefore not malleable, but falling under the hammer into powder; not dissoluble in water; nor scarce fusible by fire, but rather reducible into ashes.*

Stones, therefore, are distinguish'd from metals in their being *friable*, which is a property that even diamonds themselves are not without; notwithstanding what the antients imagined of goats blood being necessary to make 'em so: and they are distinguish'd from salts, in not *dissolving in water:* as, from sulphurs, in not *fusing by fire.*

*Division of stones.* Stones are popularly divided into vulgar, and pretious; or, which amounts to the same, into opake, and transparent*.

## PRECIOUS STONES.

*Precious.* A *Precious stone*, call'd also *gem*, and *jewel*, is that which is durable, transparent, and of a beautiful colour, or water.

Of these, there are three kinds. First, such as are entirely *transparent*; which again, are either colourless, as the diamond; or colour'd, as the emerald, &c. The 2d, brilliant, or *shining*, as the *Bohemian* granate: the 3d, *Semi-transparent*, as *Oculus cati*, opal, &c.

The division of *colour'd gems*, may be subdivided into such as have but one colour throughout; as the ruby: or such as have *several colours*, as the amethyst †.

Among

* Some other naturalists make more minute divisions: the curious and learned bishop *Wilkins*, for instance; considering stones in respect of their value, makes an intermediate kind, between vulgar, and precious, *viz. middle priz'd.*

The accurate Dr. *Woodward* chusing to consider stones, not in respect of value, which is arbitrary and extrinsic, but of something that belongs to themselves, divides them into those found in *larger masses*, and those in *lesser masses*; which latter he subdivides into such as *do not exceed marble in hardness*, and such *as do* exceed it. These last make the class of *precious stones* in the other divisions.

† Bishop *Wilkins* divides precious stones into *more* and *less transparent*. The *less transparent* he distinguishes by their colours: into red, as the sardius and cornelian; pale, fleshy colour, like that of a man's nail, as the onyx; blueish, as the turquois; pale purple, as the chalcedony; and those of various colours, as opal and cat's eye.

The *more transparent* he distinguishes into such as are colourless, as the diamond and white saphir; and colour'd, which are either red, as the ruby, carbuncle, and granate; yellow, as the chrysolite, and topaz; green, as the emerald, smaragd, and beryl; blueish, as the saphir; and purple or violaceous, as the amethist and hyacinth.

Dr.

Among precious ſtones, the firſt place is due to the diamond, or adamant, as the hardeſt, and moſt tranſparent of all others; and it may be added, the moſt ſimple, and homogeneous, too: ſo that the diamond ſeems to be that among ſtones, which gold is among metals. The pſeudo-diamond is ſufficiently pellucid, compact, and weighty; but not ſo hard, nor capable of the luſtre and poliſh of the true diamond. *Diamond the firſt in rank among precious ſtones.*

The variety of ſtones ſeems to reſult from no other than the admixture of other heterogeneous, perhaps metalline particles, with the ſimple cryſtalline baſe †. Thus, according to the ſeveral circumſtances, kinds, quantities of the ſuperadded metalline impurity, ariſe ſeveral kinds of ſtones, of ſeveral properties, colours, weights, *&c.* The cryſtal it ſelf is abſolutely pure, pellucid, colourleſs, *&c.* And that it produces ſtones which are otherwiſe, is apparently owing to ſome ſubtile metallic fumes it imbibes in the mine; and according to the different quality there ariſes a gem of this, or that denomination. Thus, *e.g.* if the acceſſionary matter be gold, it becomes a ruby; if copper, an emerald; if lapis lazuli a turcois, *&c.* laſtly, cryſtal it ſelf in all its purity and perfection, fix'd by ſome acid ſulphur, makes the diamond. *Variety of precious ſtones, whence it ariſes.*

The diſtinguiſhing mark in precious ſtones, is the ſame as in metals, *viz.* the weight ‖; nor is there any counterfeiting of ſtones more than metals, but the weight will diſcover it. All ſtones, *e. gr.* that are leſs ponderous than a diamond, *&c.* are infallibly no diamonds, *&c.* And, on the contrary, whatever ſtone has the weight of a diamond, is really a diamond **. Tho' the hardneſs, conſider'd with the weight, makes the proof ſtill more unexceptionable. *Their weight.*

Hence,

Dr. *Woodward* divides precious ſtones ſomewhat more preciſely, into opake, ſemi-opake and tranſparent. Again, 1ſt, the *opake* are either of one colour, as the turquois; or of various colours, as lazuli and jaſper. 2d, *Semi-opake*, either have their *colours permanent*, as the agat, chalcedony, onyx, ſardonix, cornelian, and beryl; or their *colours vary*, according to the poſition of the light, as the *Oculus cati* and opal. 3d, *Tranſparent ſtones* are either *with colours*; as the topaz and jacinth, yellow, or partaking thereof; granate, ruby and amethiſt, red; ſaphir, water ſaphire, and aquemarine, blue; and emerald, or cryſolite, green, or partaking thereof: or *without colours*, as the cryſtal, pſeudo-diamond, white ſaphire, and diamond.

† For the origin and formation of gems, ſee the note at the concluſion of this chapter.

‖ Dr. *Slare*, ſeems to ſtretch this point, and make the ſpecific weight of ſtones too adequate a ſtandard. He ſpeaks of ſeveral bodies, which appear, in all reſpects, like ſtones, and are commonly rank'd as ſuch; but which, by the hydroſtatical ballance, are found to want of the neceſſary weight, ſuch, *e. gr.* is chalk, and various other bodies taken for granted to be ſtones, ſome of which are nearer earths than ſtones, and others nothing but earth, ſulphur, and metal. Of the former, many fall ſhort of our ſtandard of ſtone, and others exceed it: whereas, true ſtones, ſays he, tho' differing much in hardneſs, whether pebbles, flints, petrify'd waters, *&c.* do anſwer the ſame ſtandard of ſpecific gravity as a diamond does: which is to that of water as $2\frac{1}{2}$ to 1. *Phil. Tranſact.* N° 182.

** The hydroſtatical ballance, ſays Mr. *Boyle*, is of prime uſe for diſcerning genuine

*Imperfection of the Art of making precious stones.*

Hence, the art of making factitious gems become defective on a double account: for, as we have not the art of fusing crystal, we are forc'd to work on glass, as our basis, which is far short, both in respect of weight and hardness. Were but crystal fusible; as we could tinge or colour it at pleasure, artificial gems might be made nothing inferior to native ones. 'Tis true, we have a method of giving a tincture or dye to crystals, which to the eye shall be equal to that of the richest gems: accordingly, we have seen beautiful green emeralds produced, by fusing copper in a crucible, and retaining the crystals therein for some time; but the colour, here, is only superficial; it adheres to the stone, but does not penetrate into its substance. Add, that the stone is hereby render'd full of cracks, and flaws; and so, extremely brittle. Consult Mr. *Boyle*, *of gems**.

nuine gems from counterfeits, which too often pass for true, to the great prejudice of physicians and their patients, and the great loss of lapidaries: for, as there are, perhaps, no qualities of bodies more essential than their ponderosity, so there is scarce any, wherein impostors find more difficulty to make a notable alteration, without being discover'd. In several cases, indeed, 'tis not very difficult to alter the specific weight of a particular body; yet it may be impracticable to make any considerable alteration in the quality, unless by such additions and operations as will cause a sensible alteration in some other qualities, and so subject the cheat to a discovery. He proceeds to give instances of discoveries he himself had made by this means. *Med. Hydrostat.*

* Many authors, not only among the antients, but the moderns, are full of the virtues and medicinal properties of precious stones; but their reputation, in this respect, is now not a little fallen. Yet, as the fragments of such stones are still preserv'd by the physicians, in some of the most celebrated compositions; as there are certain chymical preparations made of 'em; and as several persons of the greatest candour and experience, have related some considerable effects of certain gems, on their own particular observations; and lastly, as it is no ways improbable that some of the softer stones may have considerable operations on the human body: it might be imprudent indiscriminately to exclude 'em from any medicinal virtue at all. When much the greatest part of their traditionary qualities are set aside as fabulous, there will still remain some, on as real, and well warranted a footing, as many of our other medicines.

'Twas on such considerations, the excellent Mr. *Boyle* was induc'd to give us that fine piece of the *Origin and Virtues of gems*; the purport whereof is to make appear; "that such stones were originally in a "fluid state, or are made up of such sub- "stances as were formerly fluid; and that "many of their general virtues are pro- "bably derived from the mixture of me- "talline, and other mineral substances u- "sually incorporated with 'em; while the "great variety, and the particular efficacy "of their virtues arise from some happy con- "current circumstances of that commixture; "*e. gr.* the peculiar nature of the impreg- "nating liquor, the proportion wherein "it is mix'd with the petrescent juice, and "the like."

To support this hypothesis of the virtues of gems, he shews that several of 'em are not simple concretions of any petrescent liquors, but consist also of other mineral adventitious parts; which he argues from the separableness of such substances in some stones; the specific gravity in others; and the different tinctures to be met with in gems of the same species, as rubies, sapphires, granats, and even diamonds, of which some are yellow, some of other colours, and some green almost like emeralds. There may therefore be in some gems numberless adventitious corpuscles: but there is great reason to think that some of these corpuscles may be endued with several properties and medicinal virtues: there is a great difference among these impregnating particles, and probably a greater variety than is known by us; and lastly, many gems are

are very richly impregnated with these particles: why, then, may not they exert some power? This is the substance of what is directly alledg'd in behalf of gems.

The stress of what is objected against 'em is, "that the mineral substances they "contain, are so closely lock'd up, that "they can communicate nothing to the "body, and so can have no medicinal o-"peration; being unconquerable by so "small a heat as that of the stomach, and "other parts of the body".

Which objection might be plausible e-nough, to prevent one's ascribing any medicinal virtues to 'em *à priori*; but can conclude nothing against what is warranted by so many facts, and observations; especially, when there are several particulars, that obviate this objection. For a vigorous load-stone, tho' frequently harder than many gems, is known to emit copious effluvia; and there are many which have been found to have a manifest and inconvenient operation on the humane body, by being wore in the pocket, or long held in the hand. Mr. *Boyle* has found many transparent pebbles, which when cut would resemble diamonds, that might be immediately brought to emit copious, and strong-scented steams. And if electrical attractions be owing to the effluvia of bodies excited by rubbing; very slight alterations may suffice to procure expirations from transparent gems, many of which are electrical, and even the hardest of all, *viz.* diamonds, one of which Mr. *Boyle* kept by him, which upon a little friction, would attract very vigorously.

To that part of the objection, which pretends gems not to be digestable by the heat of the stomach, it may be replied, that we do not know how far the digestion of things in the stomach is owing to heat. Nor is it prov'd that such materials can have no operation on the body, without being digested, *i. e.* in passing thro' it, without undergoing any sensible change of bulk, figure, *&c.* as gems, when swallow'd, are suppos'd to do. For some chemists make a kind of bullets of regulus of antimony, which they call *pillulæ perpetuæ*, because when they have perform'd their operation in the body, and are cast forth with the excrements, they may be applied again and again to the same purpose. Nor do we know what analogy there may be between some juices in the body, and those mineral parts which impregnate gems: for tho' *Oculus mundi* be reckon'd among the rare gems, yet if one of the best sort, be, for a while, kept in common water, it will receive an alteration obvious to the eye. Add, that Mr. *Boyle* has, without heat, obtained a manifest tincture from several hard bodies, and even from a transparent sort of gems by means of a faint liquor, distilled from a vegetable substance, as harmless, and as plentifully eaten as bread. And whether some juices of the body, assisted by the natural heat thereof, may not serve for menstrua to some gems, we will not say: but even the natural heat of a human stomach, nay, perhaps of the external parts of the body, may be able, tho' not to digest precious stones, yet to fetch out some of their virtues: for 'tis certain, it makes a sensible alteration in the hardest sort of 'em: witness a diamond of Mr. *Boyle*'s, which might have its electric faculty excited without rubbing, only by a languid degree of adventitious heat; and another, which, by means of water made a little more than luke-warm, might be brought to shine in the dark.

Lastly, if it be yet objected, that 'tis not likely gems should part with any effluvia, or portions of themselves, inasmuch as they lose none of their weight: it may be answer'd, that the antimonial glass and cup, imbue wine and other liquors, with a strong emetic quality, without undergoing any sensible diminution of weight. Add, that tho' common water be not allow'd a menstruum fit to draw any thing from mercury; yet, both *Helmont*, and others inform us, that a large quantity of it being kept for a day or two upon a small proportion of that drug, will acquire a virtue of killing worms, tho' the mercury retains its former weight.

## VULGAR STONES.

Vulgar ſtones.

*VUlgar, or opake ſtones, are of a more earthy kind; and convertible by fire † into a calx, which, with the addition of a fix'd alcaline ſalt, becomes glaſs ‖. Such are pebbles ‖‖, flints, the *Lapis calcarius* or lime ſtone, *&c.* See *Antonio Neri, de Re vitraria***.

* E'er we paſs on from *precious* to *vulgar* ſtones, it may be proper to remind the reader, that there are certain ſtones, which partake, more or leſs, of the characters of both; and which ſome authors refer to the one claſs, and others to the other: but to us they ſeem better conſider'd, as conſtituting a claſs of themſelves. Accordingly, in biſhop *Wilkins*, they make what he calls the *middle priz'd claſs*, which includes the alabaſter, marble, porphyry, agat, jaſper, lazul, cryſtal, glaſs, ſelenites, talc, magnet, cadmia, asbeſtos, *&c.*

† For the chemical elements of ſtones, M. *Homberg* obſerves, that all we find in 'em is a deal of earth, with a little *ſulphurous* fume. *Mem. de l'Acad. An.* 1702.

‖ See what is hereafter deliver'd of the making of glaſs, in the notes at the end of the article, *ſemi-metals*.

‖‖ Vulgar ſtones are divided by biſhop *Wilkins* into thoſe of *greater magnitude*, uſed either *about buildings*, as the free-ſtone, ragg-flint, fire-ſtone, ſlate, and pebble; or about *metals*, as the whet-ſtone, touch-ſtone, emery, and pumice; and thoſe of *leſſer magnitudes*, as *ſand* and gravel.

*Origin and formation of ſtones.*

** The origin of ſtones, is a point of curious and important inquiry, and has accordingly been proſecuted by ſome of our later naturaliſts, with peculiar attention. *Boyle*, *Tournefort*, and *Geoffroy*, have diſtinguiſh'd themſelves in this reſearch.

M. *Tournefort* deduces ſtones, and other of the foſſil tribe, *ab ovo.* Nature, according to that author, obſerves one general law in the production of plants, ſtones, and metals, which all equally ariſe from their ſeveral ſeeds, and grow alike. This ſentiment indeed is not quite new: *Pliny* aſſures us, that *Mutianus* and *Theophraſtus*, maintain'd that ſtones produc'd ſtones; and *Gregory Nazianzen*, in his poem *de virgin.* relates, that there were authors who believ'd that trees made love. Ἐςι καὶ ἀψύχοισι γαμος και δεσμος ἔρωτος. But M. *Tournefort* ſets the ſyſtem in a new light, and ſupports it by arguments they were ſtrangers to: In the walls of the labyrinth of *Crete*, which are of living rock, a great number of names have been cut by perſons who have viſited the ſame. Which names, tho' originally dented, or *in creux*, are now found in Baſſo-relievo, ſtanding out from the face of the rock by ¼ of an inch. Now, this he argues, could no otherwiſe happen, but by ſuppoſing the dents gradually fill'd up with ſome matter oozing out of the rock, and which even oozed more plentifully than was neceſſary for filling the cavity. This matter, therefore, muſt have come from the body of the ſtone, and have conſolidated, or heal'd up the wound made by the knife or chiſſel, much as the callus form'd on a fractured bone by the extravaſated nutritious juice of the bone, fills up the fracture, and riſes beyond the ſurface of the bone. The like is obſerv'd in the barks of trees, cut in the ſame manner; whence the expreſſion of *Virgil*, *creſcent illæ creſcetis amores.* Laſtly, the like callus's or conſolidations were ſhewn by M. *Tournefort* to the royal academy, in other ſtones, as an *Ætites*, or eagles ſtone, and ſome others freſh dug up. From the whole he concludes, that ſtones grow in the quarry; that, of conſequence they are fed; and that the ſame juice which feeds 'em, ſerves to rejoin their parts when broken; and in a word, that they are organiz'd, and draw their nutritious juice from the earth; thro' their ſurface, which filters it, and ſerves as a ſort of bark. The progreſs and diſtribution of ſuch juice thro' all parts of ſo hard a body, he adds, is difficult to conceive; but not more ſo than that of the juice of ſome trees of very hard wood, as that of *Braſil*, call'd iron wood, that of ebony, or even coral, which all allow a plant.

Having found that ſome ſtones grow like plants; the analogy led M. *Tournefort* to imagine they might be propagated alike: and

and 'tis certain, there are ſome ſorts, whoſe generation can ſcarce be accounted for, without ſuppoſing them to have aroſe from a ſort of ſeed, *i.e.* from a germ, wherein the organical parts of ſuch ſtones were contain'd in little; as thoſe of the largeſt plants are in their grains. The cornua ammonis, lapis judaicus, aſtroites, entrochi, toad-ſtone, cryſtals, the ſeveral ſpecies of pyrites, ſea-muſhrooms, and infinite others, ſuppoſe their particular ſeeds, as much as common muſhrooms, truffles, and divers ſpecies of moſs do, whoſe ſeeds were never yet diſcovered.

The cornua ammonis, for inſtance, is conſtantly in form of a volute, and the lapis judaicus of an olive fluted without ſide: Now, whence this uniform ſtructure, unleſs from a ſeed containing it in embryo? Who moulded it ſo acurately; and where are the moulds it was faſhion'd in? nothing like 'em are ever found, even where the ſtones are in greateſt abundance. *Boot*, after abundance of enquiries about the regular figure affected by cryſtals, concludes, that it is as natural thereto as that of the leaves and flowers of any plant; and aſcribes the whole to an archetonic ſpirit, and a kind of faculty, which he calls *formatrix*. But, is it not better to ſuppoſe they have a kind of eggs; and that the juice they derive from the rock to which they grow, does, as it were, hatch, and extend 'em to their deſtin'd bulk? To ſay no more, that immenſe quantity of round pebbles wherewith the *Crau* of *Arles* is cover'd, for ſeventy miles round, ſeems to require the ſame origin; and accordingly *Fab. de Peireiſc*, who held that ſtones aroſe from ſeeds, tho' in a ſenſe different from M. *Tournefort*, look'd on this plain as a convincing proof of his opinion. *Memoir de l'Acad. An.* 1702.

But this Doctrine ſeems, in good meaſure obviated by Mr. *Boyle*; who undertakes to prove that gems, in particular, were originally in a ſtate of fluidity. This he argues from a great number of conſiderations: as 1°, The *tranſparency* of thoſe ſtones; which is a quality depending on ſuch an order of the conſtituent particles, as cannot well ariſe without ſuppoſing 'em originally capable of being mov'd with the ſmalleſt impulſe, and of giving way to the rays of light. 2°, The *figure*, which in many is determinate and geometrical, bearing a near analogy to the cryſtals which we ſee ariſe from the diſſolutions of nitre, alum, vitriol, or the like in water. 3°, The *texture*, which nearly reſembles that of ſeveral coagulations of bodies formerly fluid. Thus, diſſolv'd ſalts, ſilver, &c. are found to coagulate into maſſes, of a thin, flaky contexture; and the like texture, Mr. *Boyle* has obſerv'd in divers gems, which even to the naked eye, have appear'd full of parallel commiſſures, made by the contiguous edges of little thin plates of ſtone, lying one over another, like the leaves of a book a little open'd. Add, that the microſcope diſcovers a parallel ſtructure, even in the moſt compact of all, the diamond; whence what they call the grain of thoſe ſtones, and the difficulty, nay impoſſibility of cleaving 'em againſt this grain without breaking. 4°, The *colours* of many of 'em appearing to be adventitious, and deriv'd from ſome tinging mineral, which could not be ſo well imparted to 'em, unleſs in a ſtate of fluidity. Accordingly, many gems have been depriv'd of their colour, by continuing long in the fire; and the experienc'd *Boot* affirms, that this will hold of all gems, except the *Bohemian* granat. Hence it is that the fire alters the colours of many gems, after the ſame manner as it does thoſe of divers foſſil pigments. Hence, again, it is that tinctures are procurable from certain gems, by proper menſtrua, which appear rather to be extracts than proper diſſolutions. Add, that ſome gems, which the lapidaries, without ſcruple, affirm to be of the claſs of rubies, ſapphires, &c. are either colourleſs, or have different colours from thoſe which uſually belong to 'em. 5°, From *heterogeneous* matters being frequently found incloſ'd in ſolid gems; particularly flies, ſtraws, graſshoppers, drops of liquor, &c.

The fluid ſtate of ſtones, then, ſeems almoſt inconteſtable: and accordingly M. *Tournefort* himſelf is forc'd to allow of it in ſome caſes. He even makes uſe of the notion, to account for the formation of divers uniformly figur'd ſtones, as the ſpecies of pectinites, conchites, mytulites, oſtracites, nautilites, echinites, &c. The fluid ſeeds of thoſe ſtones he ſuppoſes to have been receiv'd into the cavities of their correſponding ſhells, the *pecten*, *concha*, *mytulus*, *oſtrea*, *nautilus*, *echinus*, &c. and thus moulded into the figures where-

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in we ſee 'em. Nor does Mr. *Boyle* himſelf conſider the liquidity of ſtones as inconſiſtent with their ariſing from a ſemen; *If there be a ſeminal and plaſtic power*, ſays he, *in ſtones, why may not it be harbour'd in liquid principles; when we ſee that the ſeed of animals, from which ariſe hard, ſolid bones, is at firſt a fluid.* But this muſt be a piece of inadvertence in thoſe two excellent authors: A fluid ſeed ſeems a contradiction. True, a ſeed may be contain'd in a fluid vehicle; which we actually ſuppoſe is the caſe in animals: but the proper ſeed or ſtamen it ſelf, inevitably muſt be a ſolid. This is obvious from the very notion of a ſeed, which is nothing but a little organiz'd body, wherein all the parts of the future production are contained in ſmall: the production it ſelf is only the ſeed enlarg'd, ſo as to ſhew its ſeveral parts to the eye. But fluidity is inconſiſtent with any ſuch organiſm: A fluid is a body whoſe parts are either actually in continual motion, or, at leaſt, are liable to be continually mov'd by the ſmalleſt force; And how can the ſtructure and arrangement of parts, which conſtitute an animal or vegetable, perſiſt in ſo ſlippery a thing, where the ſituation of the parts is continually interchangeable? 'tis no more poſſible for the ſeed, *e. gr.* of a tree, to be fluid, and yet remain a ſeed, than for the tree it ſelf to be fluid, while a tree; ſo that the ſeminal origin of ſtones does not ſeem tenable.

Monſ. *Geoffroy*, here, furniſhes us a happier ſyſtem, and more conſiſtent with the doctrine laid down by *Boerhaave*. His principle is, that earth alone, without any other mixture of ſalts, ſulphurs, or the like, is the baſis of ſtones; and the only matter neceſſary to their formation; *i. e.* the earth may be mix'd with ſalts and ſulphurs, as we actually find it is in many ſtones, but this is not abſolutely required; 'tis only by accident that it does befal; and there are other ſtones without any at all, as the common ſtones of quarries, white flints, &c.

Earth, according to this philoſopher, conſiſts of two kinds of primitive parts; the one in very thin equable plates; the other in all kinds of irregular figures. When the parts of *the firſt kind* meet together in a ſufficient quantity; the regularity, and equality of their figures, determines them to range themſelves in a regular and ſimilar manner, and thus to form a homogeneous compound, which, at the ſame time, muſt be very hard, on account of the immediate contact of its parts, and tranſparent, by reaſon of their regular diſpoſition, which leaves a free paſſage for the light every way: And this is *cryſtal*; which, accordingly, is look'd upon as the moſt ſimple, pure, and homogeneous of all precious ſtones. As to the terreſtrial parts of the *ſecond kind*, 'tis viſible they can only form opake and ſofter aſſemblages. Cryſtals, therefore, being alone form'd of the parts of the firſt kind; all other ſtones muſt ariſe from a mixture of both. Thoſe of the firſt unite, and bind together thoſe of the ſecond; which without 'em would be no more than a ſand, or duſt; and give 'em a hardneſs and conſiſtence.

To explain this more fully, he obſerves that water is a proper vehicle for the conveyance of the terreſtrial parts of the firſt kind: this is eaſily gather'd from divers petrifying waters, which line the pipes they run thro', or other bodies laid in 'em, with a cruſt of ſtone. Strictly ſpeaking, the water does not diſſolve theſe earthy parts: it only keeps 'em in fuſion, as it does the juices of divers ſorts of plants. From this reſemblance, he calls theſe parts the *cryſtalline*, or *ſtony juice*.

This juice is more heavy, and fix'd than water; and conſequently does not evaporate with it; but is left behind; and thus is the formation of cryſtal, perfectly like that of the cryſtals of ſalts. For theſe cryſtals only ariſe with thoſe regular figures they affect, when a water impregnated with ſalts, is ſlowly evaporated, in a moiſt place: the evaporation of the water is neceſſary, that it may not keep the ſalts too far aſunder; and the ſlowneſs of the evaporation, that the ſalts may have time to take that arrangement which agrees beſt with their reſpective figures. The application of this to rock-cryſtal, is obvious: there needs nothing but to conceive that a water charg'd with a good quantity of cryſtalline juice had inſinuated it ſelf thro' the clefts of ſome rock, and fallen to the bottom of a grott, where the aqueous part gradually evaporated.

It muſt be conſider'd that this cryſtalline juice is not equally diffuſed in all parts of the earth, ſo that rock-cryſtal would not

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arise in all places, even setting aside the necessity of other concurrent circumstances which do not often meet. If the water impregnated with this crystalline juice happen to penetrate a mass of earth; which is the most usual case; it will connect or bind together the parts thereof, by means of this juice; and afterwards, in proportion as the watry part evaporates, the compound will grow harder, and at last become stone. Add, that it will approach nearer to the nature of crystal, *i. e.* will be more hard and transparent, according as the quantity of that juice is greater; and at the same time of a finer grain, according as the molecules of the earth are smaller and more homogeneous. Of this kind are marbles, and alabasters, in some of which one may discern veins or threads, as transparent as if they were wholly crystal. The stones most opposite hereto, and most imperfect, are chalk and boles; which are little else but earth ill bound together with a very small quantity of crystalline juice; which leaves 'em still friable. 'Tis easy to imagine infinite degrees between these.

The particular circumstances which attend the formation of stones, vary the effect of these general principles divers ways. For instance, if a portion of this crystalline juice, diluted in water, chance to be surrounded with earth; and the juice be not in quantity sufficient to petrify the the whole earth as fast as the water evaporates; there will arise a mass, partly crystalline and transparent, and partly opake, dissimilar and earthy. If the same crystalline juice be in the middle of the mass; only the middle will be transparent, and cover'd over with an opake crust. Such are agats, *&c.* On the contrary, if the crystalline juice, be, by any cause whatever, driven from the centre toward the circumference; there will be a pure earth in the middle of a stone, tolerably transparent. Such are divers flints, *&c.*

# *Fourth Claſs of Foſſils.*

## EARTHS.

Earth, AFter *ſtones*, the next bodies in point of ſimplicity, are *earths*; which are diſtinguiſhable into two claſſes or kinds; *viz.*

1°, *Sands* *, which are properly little cryſtals, or tranſparent pebbles, calcinable; and, by the addition of a fixed alcaline ſalt, fuſible, and convertible into glaſs: and, therefore, in propriety belong to the article of *ſtones* †.

Defined. And, 2°, *Earth* properly ſo call'd: which is a *foſſil body, neither diſſoluble by fire, water, nor air; inſipid* ||, *and untranſparent; more fuſible than ſtone; ſtill friable; and containing uſually a ſhare of fatneſs* **.

Earths, in this ſenſe, are divided into *ſimple*, or immutable; and *compound* ††.

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* 'Tis the character of ſand not to be calcinable by fire, as flint, and other ſtones are; and yet it agrees with flint, and ſome metals in this, that it ſtrikes fire from ſteel. But it muſt be obſerved, this only holds of the *proper* or *mountain* ſand; for a great part of what commonly paſſes for ſand, is not originally ſuch, but only a duſt or powder ground or broke off other ſtones by their attrition againſt each other; and denominated ſand for no other reaſon but the ſmallneſs, little coheſion, and dryneſs of the grains. The real ſand, Dr. *Liſter* obſerves, is of a conſtant figure, and always preſerves its original magnitude.

From the great hardneſs, and, conſequently, durableneſs, and unalterable Quality of this foſſil above all others, together with ſome other conſiderations; that author concludes it to have antiently been the exterior, and moſt general cover of the ſurface of the whole earth. *Philoſ. Tranſact.* N° 164.

† Dr. *Liſter* divides the *Engliſh* ſands into two claſſes: the firſt, *ſharp* or *rag-ſand*, conſiſting of ſmall, tranſparent pebbles, naturally found on the mountains, and not calcinable. Theſe he further divides into *fine*, and *coarſe*; and ſubdivides each, according to the colours, into white, grey, reddiſh, brown, &c.

The ſecond, *ſoft* or *ſmooth*; which he ſubdivides into that with *flat* particles, broke from lime-ſtones; that with *ſilver-like* particles; and that with *gold-like*. *Phil. Tranſ.* N° 164.

|| 'Tis diſputed among the peripatetic and chemic philoſophers, what ſpecies of bodies the calces or aſhes of burnt bodies ought to be rank'd in: the firſt refer them to earth, becauſe of their permanency, and fixedneſs; but the latter will have them a body *ſui generis*, as commonly containing a cauſtic ſalt; whereas earth ought to be inſipid. *Boyle on the Reſurrec.*

See the chapter of *Earth* conſider'd as an inſtrument or element.

** The mixture of ſand and clay, Dr. *Liſter* obſerves, is not unuſually call'd *earth*; a term ſomewhat too vague, and which it would be convenient to limit to that mixture which we ordinarily find upon the ſurface of the ground; and which, beſide the two ingredients above-mention'd, contains a great deal of the parts of putrified plants and animals. *Philoſ. Tranſ.* N° 164.

†† There is, perhaps, no ſuch thing as a ſtrictly ſimple earth. "It does not appear," ſays Mr. *Boyle*, "that nature, any "more than art, affords any elementary "earth: at leaſt, ſome which appear of "the ſimpleſt ſorts, are found upon exami-"nation

Of the firſt kind is *chalk* ||||, which is the ſimpleſt, and drieſt of all *earths*; as having no diſcernible ſhare of fatneſs at all. To this kind are reducible *pumice*, *rotten-ſtone* *, &c. *Simple earths.*

Among the *compound* or fatty earths, are number'd *boles* of divers kinds, *red*, *white*, and *brown*; moſt *clays* †; *fullers earth*; the divers kinds of medicinal earths, as *Cretica*, *Tockavienſis*, *Hungarica*, *Turcica*, *Sileſiaca*, *Suecica*, *Lemnian earth*; *Malta earth*; *Terra ſigillata*, *ſoap-earth*, &c. To theſe are likewiſe refer'd all *argillæ* or fatty clays, wrought up, and dried into potters ware. *Compound ones.*

There are divers other ſpecies of compound earths ||; *Rivinus* reckons

"nation to have qualities not aſcribed to "pure earth." *On Chym. Prin.* See further in the chapters, *Of Operations*; and *Of Earth*, as an inſtrument.

|||| The antients, and many of the moderns, refer chalk, which they call *creta*, and pumice, *pumex*, to the claſs of ſtones; but 'tis with better reaſon they are accounted *earths*. Dr. *Slare* complains, that our ſenſes frequently impoſe on our underſtandings, in repreſenting that as a ſtone by its external appearance, which has none of the diſtinguiſhing characters of ſtone. He inſtances in chalk, which, brought to the hydroſtatical balance, is found to want much of the conſiſtence, and weight which is required to a real ſtone.

* Several ſpecies of clays ſeem to have a fair title to the rank of ſimple earths: tho', on a ſtrict examen, they appear very compound. Thus tobacco-pipe-clay, by reaſon of its fixity, whiteneſs, and inſipidity, Mr. *Boyle* thinks, may, with almoſt as much probability as any other native earth, be accounted elementary: and yet tobacco-pipes well baked, may ſometimes be made to ſtrike fire; and we have ſeveral times found, that by briskly rubbing two pieces of a new tobacco-pipe, they would in a minute or two grow warm; and being immediately ſmelt to, manifeſtly afford a rank ſcent, between ſulphurous and bituminous; almoſt like that which proceeds from pebbles and flints rubbed hard againſt each other: as if tobacco-pipe-clay were not a true earth, but a fine white ſand, conſiſting of grains too ſmall to be diſtinctly ſeen. *Boyle Mech. Produc. of Chym. Prin.*

Porcellane, or the matter whereof *China* diſhes are made, is a pure ſort of clay; and yet a violent fire will ſometimes make it melt; and it will ſtrike fire with ſteel, almoſt like a flint; to which it approaches in ſpecific gravity. The like we have obſerv'd of porcellane very artfully imitated with a ſort of *Engliſh* clay. *Id.ibid.*

† Dr. *Liſter* makes *clay* a *genus* of almoſt as much extent as *earth* itſelf. In his ſcheme of clays, he divides them into two grand claſſes, *pure*, *i. e.* ſuch as are ſoft, like butter to the teeth, and have little or no grittineſs; and *mix'd*.

*Pure clays* he ſubdivides into *greaſy*, which include the medicinal earths, or *terræ ſigillatæ*; as fullers earth, yellow, brown, and white; boles; cow-ſhot-clay; and a dark blue clay: *harſh* and *duſty*, when dry, as *creta*, properly ſo called, or the milk-white clay of the *Iſle of White*; potters clay, yellow, blue, and red: and *ſtony*, when dry, as the ſeveral ſorts of ſtone-clays, and clunch.

*Mix'd clays* he ſubdivides into thoſe *with round ſand or pebble*; as the yellow loam of *Skipworth-Moor*; the red ſandy clay near *Rippon*, *&c.* and thoſe with flat or thin ſand glittering with *mica*; as crouch-white clay, grey or blueiſh tobacco-pipe-clay; and a red clay in the red ſand rock at *Rotheram*. *Philoſ. Tranſact.* N° 164.

|| *Vannochio*, an eminent *Italian* mineraliſt, informs us, that a ſort of reddiſh earth oft contains the richeſt metals. Mr. *Boyle* has found finely figured cryſtals to grow in a red earth. An experienced writer on the gold and ſilver mines of *America*, obſerves, that gold itſelf is often diſguiſed under the appearance of a reddiſh earth. And our *Engliſh* okers are richer in iron even than ſome ores of that metal. Add, that the ſame Mr. *Boyle* had a whitiſh earth ſent him out of the North of *England*, which contain'd a conſiderable quantity of lead.

 above

above a hundred ſorts of *ſigillatæ* or ſeal'd earths; the hiſtory whereof has been long expected with ſome impatience.

*Its principles.* Theſe earths are all reſoluble into a little ſulphur or oil, a little acid, and leſs fixed ſalt, and a calx, which is the baſis, or properly the earth itſelf.

*Sand.* As to *ſand*, its office is to make the fatty earth be fertile, and fit to feed vegetables, &c. For, earth alone, we find, is liable to coaleſce, and gather into a hard, coherent maſs; as is apparent in clay: and earth, thus imbodied, and as it were glued together, is no way diſpoſed to nouriſh vegetables. But if with ſuch earth, ſand, *i. e.* hard cryſtals, which are indiſſoluble in water, and ſtill retain their figure, be intermixed, they will keep the pores of the earth open, and the earth itſelf looſe and incompact; and by that means give room for the juices to aſcend, and for plants to be nouriſhed thereby.

Thus, a vegetable, planted either in ſand alone, or in a fat glebe or earth alone, receives no growth or increment at all; but is either ſtarved or ſuffocated: but mix the two, and the maſs becomes fertile. In effect, by means of ſand, the earth is render'd in ſome meaſure organical; pores, and interſtices being hereby maintain'd, ſomething analogous to veſſels; by which the juices may be convey'd, prepared, digeſted, circulated, and at length excern'd, and thrown off into the roots of plants *.

* See the chapters of vegetables.

*Fifth*

# *Fifth Claſs of Foſſils.*

## SULPHURS.

SUlphur is a *foſſil body, fuſible and inflammable by fire, and not diſſolvable or miſcible in water, nor malleable.* Sulphur defined.

Theſe ſix properties concurring, form the idea of a *ſulphur*; nor is there any other body in nature wherewith they all quadrate.

It muſt be owned, however, that ſpirit of wine, which is a ſulphur, is miſcible with water; but it is owing to this, that the ſulphur in ſpirit of wine is ſo changed, and its parts ſo attenuated, and divided, as to inſinuate themſelves among the parts of the water, where they would not otherwiſe be admitted *.

We call it *foſſil*, to diſtinguiſh it from the ſulphur of metals, call'd alſo the *ſulphur of the philoſophers.*

*Inflammable by fire, i. e.* reducible by fire into flame, and aſhes; which are its principles; the *flame* being a volatile, acid ſpirit; and the aſhes, earth, with a little metal therein, reſembling iron.

*Fuſible*; in which ſtate the fume it emits, corrodes, and conſumes all metals; converting them into vitriols, which are a ſpecies of ſemi-metals. Thus, iron, which abounds in ſulphur, being heated, tho' not ignited; the ſulphur is found to kindle, and go off in a blueiſh flame.

Sulphurs are divided into two claſſes, *viz. ſolid* and *liquid* or at leaſt *liquifiable* by the gentleſt heat. Divided.

### *The ſolid Sulphurs are,*

1°, COmmon *ſulphur*; of which there are two kinds; the firſt, *ſulphur vivum*, which is a native ſulphur, found under ground, in ſolid, grey, or aſh-colour'd glebes, like rock-ſalt; in divers places, but chiefly the iſland *Sicily*. This, *Helmont* accounts an antidote againſt the plague. Sulphur vivum.

2°, *Yellow ſulphur*, or the vulgar ſulphur of the ſhops, is only the former kind melted down by a violent fire, and run into cylinders †. This, Yellow ſulphur.

* In ſpirit of wine, and other fermented liquors, what we call the *ſulphur* of the concretes, or bodies they are procured from, loſe, by fermentation, that property of oil or ſulphur which makes them immiſcible in water. *Boyle's Sceptical Chymiſt.*

† By the way, it is to be obſerved, that the ſulphur commonly uſed among us, is not that from *Sicily* alone, thus melted down; but there is another ſpecies of native or mineral ſulphur found, of a hard, earthy conſiſtence, and a ſhining yellow colour; chiefly around *Volcano's* or burning mountains, particularly mount *Veſuvius*, and *Ætna*; and ſometimes alſo in its own mines, both in *Italy*, *Switzerland*, and the *Spaniſh America*. 'Tis chiefly of this that the ſticks or rolls of ſulphur are made.

the more fluid it is made, the better it is; and the more cineritious, or dark-colour'd, the worſe: if it be blackiſh, it has a deal of arſenic in it.

Both theſe kinds of ſulphur are exceedingly inflammable; more ſo than ſpirit of wine ||: They melt readily by fire, and as readily grow hard again in the cold. They render metals, when mixed therewith, exceedingly brittle; ſo that 'tis in vain ſome alchemiſts have attempted to find the philoſopher's ſtone in common ſulphur, which itſelf deſtroys the malleability of metals.

*Arſenic.* The ſecond is *arſenic*; the moſt fatal of the whole tribe, as deſtroying all animals, both man and beaſt; which the word itſelf imports; being compounded of ανερ, man, and νικαω, I overcome.

In an antient manuſcript aſcribed to the *Sybils*, is a verſe which plainly intimates arſenic: *Tetraſyllabus ſum: prima pars mei virum, ſecunda victoriam ſignificat.* Whence ſome have been induced to ſeek the philoſopher's ſtone therein.

*Orpiment.* Native arſenic is of a yellow or orange-colour; whence it is alſo denominated *auripigmentum*, or *orpiment* **. Of this are prepared two other kinds of arſenic, *viz. white* and *red.*

*Realgal.* *Red arſenic*, call'd alſo *Realgal* ††, is only the native yellow, rubified by fire. And this, ſublimed with ſome other matters, is the *Sandaracha Græcorum.*

The *white* or cryſtalline, is drawn from the yellow, by ſublimation ||||.

The ſmalleſt quantity of any of theſe arſenics being mixed with any metal, renders it friable, and abſolutely deſtroys its malleability *. And hence the refiners dread nothing ſo much as arſenic in their metals; nor could any thing be ſo advantageous to them, were ſuch a thing to be had, as a *menſtruum* that would abſorb, or act on arſenic alone: for then their metals would be readily purified, without flying off or evaporating.

|| Sulphur contains ſome parts which render it more inflammable than either nitre or oil; and yet abounds with acid, and vitriolic particles, which ſtrongly reſiſt the flame in ſeveral other bodies: the fire of ſulphur, beſide its common effect, ſeen in matches, in another capacity, acts by means of its acidity upon ſome metals, eſpecially iron; and alſo on red roſe-leaves, which are turn'd white by its fumes. *Boyle Uſeful. of Exper. Philoſ.*

** It is chiefly found in copper-mines, in a ſort of mineral ſtones, of different figures, and ſizes. Its colour, tho' always yellow, yet admits of divers ſhades and mixtures, as a golden yellow, reddiſh yellow, green yellow, &c. It is found to contain a portion of gold; but ſo little, as not to quit the coſt of ſeparating it. See page 11.

†† Tho', ſome naturaliſts will have *red arſenic*, and *realgal*, two diſtinct drugs; taking the latter for a native mineral, and the former for a preparation of native arſenic.

|||| 'Tis this ſpecies is chiefly in uſe among us for real arſenic. Some authors give it a different origin; and maintain it a native matter, found in white ſcaly glebes, in the mines.

* A ſingle grain of arſenic, mix'd with a pound of copper, turns it into a beautiful ſeeming ſilver. This hint many perſons have endeavoured to improve on, for the making of ſilver; but in vain, as it could never be brought to ſuſtain the hammer. Some have been hang'd for coining ſpecies of this ſpurious ſilver.

Arſenic

Arſenics do not diſſolve in water, but hang therein, after the manner of feathers. Fire readily fuſes 'em: and they erode, and wonderfully alter all metals †.

3°, *Bitumen*, which is an imperfect, fatty ſulphur, conſiſting of an oil, and the vague acid combin'd: for of ſuch principles it may be compounded by art. Thus the acid ſpirit of ſulphur, and oil of vitriol diſtilled together, yield a ſort of *Bitumen*, which liquifies by the fire, *&c.* *Bitumen.*

Bitumen is of various colours and conſiſtences; whence it is diſtinguiſhed into various kinds*: the moſt eminent, and that which gives the denomination to the reſt is,

*Aſphaltum*, *piſaſphaltum*, *bitumen judaicum*, jewiſh pitch or *bitumen* properly thus call'd, which is a fatty glebe, or ſcum, gathering on the ſurface of the dead ſea. *Aſphaltum.*

This ſpecies is furtheſt maturated and concocted of the whole bituminous kind, but it conſiſts of the ſame ſimple principles as the reſt. 'Tis but rarely found in our ſhops: its name piſaſphaltum intimates it to partake both of *pitch* and *bitumen*; which ſome ſay is owing to its being adulterated with pitch: tho' others take its pitchy property to be natural ||.

As it is liquid in its firſt ſtate, it will require a place among the liquid ſulphurs.

But there is another aſphaltum, which is a mineral ſtone, found in the valley of *Sydim*, near the antient *Babylon*, and lately alſo in the County of *Neuchatel*, the oil whereof makes an excellent cement, incorruptible by many acids, and ſuppoſed to be the mortar, ſo much celebrated among the ancients, wherewith the walls of *Babylon* were laid.

5°, *Amber*, or *ſuccinum*, about which there is ſome diſpute ** whether it be a vegetable or a mineral production: but it has the faireſt pretenſions to *Amber.*

† Arſenic, whatever ſome may urge, ſhould never be given inwardly; as being a moſt deadly poiſon, gnawing, and tearing the parts, and occaſioning mortal convulſions. Its fume taken into the lungs kills inſtantly. And the oftner it is ſublimed, the ranker it grows. The younger *Helmont* ſeems to intimate, that arſenic would fix mercury; but the operation muſt be extremely dangerous, the leaſt breath of it being fatal.

* Some naturaliſts, as Dr. *Woodward*, &c. extend *bitumens* into a general claſs, anſwering, in great meaſure, to the claſs of *ſulphurs*. Accordingly they ſubdivide 'em into *liquid*, or *napthæ*, including petrol, and oleum terræ; and *ſolid*, under which they range amber, jet, bitumen, aſphaltum properly ſo call'd, and coal.

|| It is of a ſhining black colour, and ſo like *Stockholm* pitch, that were it not for the rank ſmell of that pitch, and the ſuperior hardneſs of the bitumen, there would be no diſtinguiſhing 'em.

'Tis uſual to ſophiſticate the aſphaltum, by mixing pitch along with it; the reſult whereof makes the piſaſphaltum; which the coarſeneſs of the black colour, and the fetid ſmell eaſily diſcover.

** Amber is uſually yellow and tranſparent, ſometimes red: its taſte is reſinous, and its ſmell like that of oil of turpentine. It is chiefly found in the *Baltick-Sea*, and along the coaſts of *Pruſſia*. Naturaliſts have been extremely in the dark about its origin and formation, ſome have maintained it an animal ſubſtance, form'd, by concretion, of the tears of birds; or according to others, of the urine of a beaſt: others take it for a reſinous juice, oozing from poplers, and firs, frequent on thoſe coaſts, and diſcharged into the Sea; where undergoing

to be a fossil; inasmuch as by distillation it yields an acid spirit, which precipitates into a salt; which is a peculiar circumstance in the distillation of minerals, never found in that of vegetables or animals.

To this species may likewise be referred *jet**, or black amber; and *ambergrease* †, or grey amber.

## *Liquid Sulphurs.*

*Asphaltum.* THE first is *asphaltum*, or *pisasphaltum*, or *jewish pitch*, a sort of bitumen, or viscid fatty juice, found on the surface of the lake *Asphaltos* or dead sea, in *Judea*; which tho' at first liquid, yet hardens in the air, and is brought to us in a firm consistent mass. So that it is rather to be ranked among the solid than the *liquid sulphurs*.

*Naptha.* The second is *naptha*, a ruddy fat, or axungia, exuding out of a rocky, or stony earth; exceedingly inflammable, so as to catch fire even from a candle held at distance; and so combustible as to continue burning under water.

dergoing some alteration, it is thrown ashore, in this form: but the generality of authors contend for its being a bitumen, which trickling into the sea, from some subterraneous sources, and there mixing with the vitriolic salts, which abound in those parts; it becomes congeal'd or fix'd thereby; the result of which congelation is amber. But what a little disturbs this doctrine, is, that good amber is frequently found in digging far from any sea-coast; which confirms it a thorough fossil.

There are several indications, which discover where this amber is to be found: the surface of the earth is there cover'd with a soft scaly stone; and vitriol in particular abounds there. Amber assumes all figures under ground, that of a pear, an almond, a pea, &c. among others, there have been found letters very well form'd, and even *Hebrew* and *Arabic* characters; within some pieces of amber have likewise been found leaves, insects, &c. included: this, with some, passes as a proof that amber was originally in a fluid state; tho' others rather account for it by supposing the amber to have been exposed to the heat of the sun, and by that means soften-ed, so as to become susceptible of the leaves, insects, &c. which opinion is countenanc'd by this, that those heterogeneous matters are never found in the center of the piece, but always near the surface.

* Jet or gagates is a sort of black, mineral stone; which admits a good polish, and has all the properties of yellow amber. There are quarries of jet in divers countries.

† Ambergreese is found on the sea-coasts; particularly those of *Africa*, from the *Cape of Good Hope* to the *Red Sea*, and the adjacent Islands; in some places of the *Mediterranean*, and about the Island of *Bermudas*, in *America*.

There are various opinions as to its origin; some take it for the excrement of a bird, which being dissolved by the sun's heat, and wash'd off the shore by the waves, is swallow'd by whales, who return it in the condition we find it: others imagine it a sort of gum, which distilling from trees, drops into the sea, where it congeals into ambergrease.

Others suppose it a sort of spongeous earth, which the working of the Sea washes off the rocks; where, being lighter than water, it floats; others contend, for its being form'd from honey-combs, which fall into the sea from the rocks, where the bees had form'd their nests; which opinion begins to be generally allow'd, several persons having seen pieces, half ambergrease, half honey-comb.

Lastly, others will have it a sort of bituminous juice, which springs out of the bottom of the sea, as naptha does out of some springs; and there thickens and hardens.

'Tis

'Tis found in ſeveral parts of *Chaldea*, particularly the place where ſtood the ancient *Babylon*; as alſo in *France*, and ſome other Countries of *Europe* That of *France* is like melted pitch, very black, and of a rank ſmell.

The third is *petroleum*, or *oleum petræ*, a fatty liquor, trickling out of rocks; frequently confounded with *naptha*, tho' it be very different therefrom, as being thinner, more penetrating, and leſs inflammable *. *Petrol.*

The fourth is *oleum terræ*, or *oil of earth*, which is of two kinds; the one call'd *Aſiaticum*, as being brought from *Aſia*; and the other *Piſellæon*, or *Barbadenſe*, becauſe brought from *Barbadoes*. *Oleum terræ.*

The firſt appears to be a ſort of liquid bitumen, of a ruddy colour; the ſecond is black: but whether the origin of the two be alike, or not, we will not ſay. This, however, we are aſſured of, that a certain celebrated Hiſtorian, who ſays this oil diſtils out of rocks, is miſtaken; that being a circumſtance peculiar to naptha, and petroleum, which are craſſer, and more conſiſtent than this oil.

We have made a nice enquiry into this *oleum terræ*; particularly whether ſo thick an oil could be produced, as is commonly ſuppoſed, by the earth; and whether the ſoil where it was generated, were fertile; and received for anſwer, from a very intelligent perſon, governor of the *Dutch Eaſt-Indies*, that this oil of earth, is really the oil of coco-nut; only mix'd up with earth, and again expreſſed out of the ſame. Such is the natural hiſtory of this oil; in which all hiſtorians have been overſeen; imagining it to diſtil out of the natural earth.

Sulphurs, of all kinds, being laid on the fire, break into flame; which yields a pernicious ſmoak; and this, when collected, is always found acid. What remains after the flame or combuſtion is extinguiſhed, affords an oil, out of which an acid ſpirit may be drawn; and which at bottom leaves a ſort of earthy or metallic matter, which a further fire converts into glaſs †. *Elements of ſulphurs.*

But if either the acid fumes, or the oil, or the ſpirit of ſulphur, be caſt on oil of olives, or any other oil, there ariſes a pitchy matter, which by ſublimation affords a bitumen; and the bitumen ſublim'd again,

* It is found in ſeveral countries, particularly the Dutchy of *Medena* in *Italy*; and is of ſeveral colours, red, yellow, green, white, &c. which diverſity is ſuppoſed to ariſe from the different ſituation of the rock, with reſpect to the ſun: thus the white, which is reputed the beſt, is ſaid to proceed from that ſide moſt expoſed to the ſun's rays; then the red, then yellow, &c.

† The chemiſts find the analyſis of ſulphur very difficult: 'tis ſo volatile, and its parts, withal, hang ſo together, that it requires a deal of pains, and addreſs to ſeparate 'em. Sir *Iſ. Newton*, to account for this, argues that ſulphur, like vitriol, is a mixture of volatile and fix'd parts, cohering ſo ſtrongly by their mutual attraction, as to aſcend together in ſublimation. He adds, that by diſſolving flowers of ſulphur in oil of turpentine, and diſtilling the ſolution, ſulphur is found to be compos'd of an inflammable thick oil, or fat bitumen, an acid ſalt, a very fix'd earth, and a little metal.

and again, yields ſulphur; which being kindled, a ſpirit of ſulphur is rais'd therefrom. It appears, therefore, that all ſulphurs are reſolvable into oil, acid, and earth *.

* Sulphur thus decompounded may be recompounded by the reunion of its elements. Thus M. *Homberg*, having with great care and accuracy reſolved the body of common ſulphur into an acid ſalt, a bituminous ſubſtance, and an earth mix'd with a ſmall quantity of metal; M. *Geofroy* recompoſed thoſe principles into true inflammable ſulphur; only, for the laſt ingredient, ſubſtituting oil of tartar. *Mem. de l'Acad. An.* 1703. See further in the article of *the operations*.

Sixth

# *Sixth Claſs of Foſſils.*

## SEMI-METALS.

A Semi-metal is a *foſſil body not malleable, yet fix'd in ſome meaſure in the fire; conſiſting of a metallic part, and ſome other matter of another kind, connected therewith:* or a *Semi-metal* is a *compound foſſil body, wherein, by art, we diſcover ſomething in all reſpects like metal, except that it is not malleable; joined with ſome other of the foſſils above related, as* ſalt, ſulphur, ſtone, *or* earth. *Semi-metal.*

Such is the genuine notion of a ſemi-metal; about which, the naturaliſts have always talk'd ſo obſcurely. Indeed, 'tis impoſſible to give a preciſe definition; by reaſon the part that is not metal, may be diverſe; but we may be aſſured it[a] is ſome one of the five other claſſes of foſſils already deſcribed.

We don't know of any way of converting *ſemi-metals* into *metals, i. e.* of rendering the part which ſeems metallic, malleable: experiments we have made a great number, after *Helmont*'s manner, to reduce the metallic part of that celebrated ſemi-metal antimony, into a real metal; but ſtill without ſucceſs; having never been able to purge it ſo thoroughly of ſulphur, as to render it ductile under the hammer. That there was ſtill ſulphur remaining, appeared hence, that being laid under copper, it would ſtill whiten, or ſilver it. This, however, we conſtantly obſerv'd, thro' the courſe of the operation, which laſted almoſt a year, that the more of the ſulphur was got out, the brighter, finer, and harder did the matter ſtill become. And we are of opinion, that if any menſtruum could be diſcovered, powerful enough to free it of all its ſulphur, we ſhould have a new metal; antimony appearing to be of an intermediate nature, between gold and ſilver. *Not convertible into metal.*

In effect, a menſtruum, or magnet, that would abſorb the ſulphur, *i. e.* by its magnetic force would draw the ſulphur to itſelf; would be no inconſiderable ſecret. I tried ſalt of tartar, which is allowed to attract iron; but this would not do: iron is a yet ſtronger magnet, but this is ineffectual to gold and ſilver. I made a trial with mercury, but could not effect the thing in a whole year's time; tho' in that time I procured a matter nearly of the colour and weight of ſilver: but ſtill it was friable. *Deſideratum.*

Semi-metals are divided, with reſpect to the matter adhering to the metal, into four claſſes.

The firſt are thoſe, conſiſting of a metal joined with a foſſil ſulphur, either common or arſenical; according to which the ſemi-metal becomes either poiſonous or otherwiſe. 'Tis notorious, that foſſil, or combuſtible ſulphur, adhering to any metal, renders it ſoft, and prevents its malleabi- *Kinds of ſemi-metals.*

 lity;

lity; and when that is ſeparated therefrom, the pure ſulphur of the metal, ſay the chemiſts, gives it a property, which the foſſil one took away. The ſulphur, which prevents malleability, is uſually called external; and held to be of a quite different kind from the metallic or internal ſulphur. To the claſs of ſulphurous ſemi-metals belong,

### SEMI-METALS *of a Metal and Sulphur.*

*Antimony.* 1°, IS *Antimony*, which conſiſts of three different parts, *viz.* 1°, common ſulphur: 2°, ſulphur, which, in the fire, yields a poiſonous ſmoak, and renders metals friable: 3°, metal; tho' of what kind, we don't certainly know. Its character, ♁ we have already obſerv'd denotes gold at bottom, and a corroſive acid at top. If there be any metallic body, that can reſolve gold into its firſt principles, it ſhould ſeem to be regulus of antimony *.

*Cinnabar.* 2°, *Cinnabar*, which conſiſts of common ſulphur, and quickſilver united into a maſs. It is ſometimes found in large glebes †; and is ſometimes factitious ‖.

*Marcaſite.* 3°, *Marcaſites* **, which are a ſort of ſtones or mineral clods, either of a gold or a ſilver colour. All that is wanting to render theſe perfect metals, is malleability: in other reſpects they are more beautiful than moſt metals *†. They conſiſt of an arſenical ſulphur, intimately mix'd with a metal:

* Antimony has its own mines, particularly in *Hungary*, *Tranſylvania*, *Germany*, and ſeveral provinces of *France*. 'Tis found in glebes or clods of different ſizes, bearing a reſemblance in figure to black lead; only that it is lighter and harder; whence it is call'd *marcaſite of lead*. It diſſolves with difficulty by fire; much eaſier in water. *Baſil Valentine* obſerves, that there are various kinds; two eſpecially; the one more mercurial, and of a golden property, manifeſt by the ſhining ſtreaks it abounds with; the other more full of ſulphur. That ſold by the druggiſts for crude antimony, is not really ſuch as it comes out of the mine, but melted down and purified.

† Cinnabar is found in all the quickſilver mines; tho' it has likewiſe its own mines: whereof thoſe in *Spain* are famous. It may be eſteem'd as the marcaſite of quickſilver, or rather as quickſilver it ſelf, fixed and petrified by means of ſulphur, and ſome ſubterraneous fire. Accordingly it is eaſily reduced, without much diminution, into real fluid mercury. See the Article *Mercury*.

‖ The factitious cinnabar, is an imitation of the native; made by a mixture of mercury, and ſulphur ſublimed, and reduced into maſſes or lumps.

** Note, the word marcaſite is ſometimes uſed in a more extenſive ſenſe, for what we otherwiſe call *pyrites*; of which by and by.

*† The reſemblance *marcaſites* bear to metals, or metalline ores, makes 'em frequently be miſtaken for ſuch; in effect, many of 'em have two qualities, which render 'em extremely apt to impoſe on the unwary, *viz.* ſhining ſtreaks like gold or ſilver; and a weight equal, nay and ſometimes ſuperior to that of true metalline ores. The grand criterion of metals, therefore, *viz.* *ſpecific gravity*, here fails us; in lieu of which, to prevent being deceived by any ſuch ſpecious ſubſtance, we are to have recourſe to the fire: for placing the marcaſite in a ſtrong fire, and blowing now and then with a pair of bellows; the ſulphur wherewith it abounds, will take fire, and burn with a flame for the moſt part blue, like that of common ſulphur: Inſomuch

metal: when thrown on the coals, they yield a white ſmoak; which renders metals friable.

The chemiſts find a real combuſtible matter in tin; which when ſeparated from the metal, leaves it in all reſpects like ſilver: and marcaſites contain a like ſulphur; for we find in them a combuſtible matter, which yields a ſuffocating ſulphur; and the glebe becomes ſo much the more beautiful, as more of the flame is exhauſted. If therefore a body could be found that would conſume ſulphur, the metal would be left alone ||.

4°, *Biſmuth* *, which is a ſpecies, of that ſort of marcaſite, which approaches neareſt to the nature and colour of ſilver. *Biſmuth.*

5°, *Lapis calaminaris* **, which if melted with copper, adds a real metallic ſubſtance and weight thereto; but diminiſhes its malleability: the maſs reſulting from the two, is braſs. It is a very great abſorber of acids; and as ſuch is of notable uſe in chirurgery. *Calamine.*

6°, *Cobalt*, which is, as it were, the mother of arſenic: it conſiſts of ſilver, and arſenic. The arſenical part being exhaled, leaves behind it a metalline calx ||*. Its fumes are violently poiſonous, infect the lungs, and give *Cobalt.*

much, that Mr. *Boyle* aſſures, he procured by diſtillation, four ounces of good brimſtone from three pounds of theſe ſtones. And if when this foſſil ceaſes to flame and ſmoak, it be taken out of the fire, and ſuffer'd to cool, it will be depriv'd of all its gaudy appearance, and turn'd to a blackiſh brittle ſubſtance, nothing like to a metalline ore. *Boyle Med. Hydroſt.*

Marcaſites, however, the ſame author obſerves, may be look'd on as a kind of metalline bodies; he having found ſeveral of them to contain particles of copper, and iron; as *Kentmannus* mentions others that contain ſilver, others gold, and others both. Mr. *Boyle* gives another inſtance of running mercury contained in, and procured from a marcaſite: he adds, that it may be poſſible for a skilful perſon to make a profitable uſe of marcaſites, either by fixing the volatile gold, or ſilver contain'd therein; or by graduating ſilver by their means. *Ibid.*

|| *Sit penes authorem fides.*

* Some naturaliſts will have biſmuth to be of two kinds; the one *native*, or *foſſil*, found in tin-mines, and ſometimes alſo, if we may credit *Alonzo Barba*, in mines of its own. It is a hard, heavy, brittle matter, of a coarſe grain, white, and glittering: Authors commonly look on it as the marcaſite or mother of tin; tho' ſome go further, and maintain it to be tin it ſelf, only not arrived at maturity, for want of ſufficient coction. The *artificial* is prepared from tin, by cementing thin plates thereof with a mixture of white tartar, ſalt-peter and arſenic.

** Cadmia, calamine, or lapis calaminaris is of divers colours, ſome white, ſome reddiſh, ſome greyiſh, and ſome blackiſh, which is reckoned the beſt; and this again, when broken, is variouſly colour'd. 'Tis found in veins, or ſeams, running between rocks; and is dug like lead ore: they always find eyes of lead in the calamine.

In the works near *Wrington* in *Somerſetſhire*, when they have landed a good quantity of the mineral, they waſh, and clean, or *buddle* it, by working and turning it in a running water, which carries off the impure earthy parts, leaving the lead and calamine, with the other heavier, ſtony, and ſparry parts behind. Putting this into ſieves, which they dip and ſhake in a tub of water; the lead gets to the bottom, and the ſparry parts to the top; leaving the calamine in the middle, which they proceed to bake in an oven much like that of a bake-houſe. In 4 or 5 hours, they take it out and beat it to powder with large hammers. *Philoſ. Tranſact.* N°. 198.

||* Cobalt is a grey ſhining ſtone, found in abundance in the mines in *Hermanduria*. 'Tis often mix'd with marcaſite, ſometimes with

give phthisics; and it is so sharp, that it corrodes and ulcerates the hands and feet of the workmen employ'd in digging it, *&c.* Divers deadly poisons are prepared from it.

7°, *Pyrites,* which is a sulphurous stone, found in most mines. It is the most fertile and pregnant of all minerals; most metals, salts, and sulphurs being supposed to be derived out of the same; especially vitriol, and copper *.

8°, *Zink* †, which resembles bismuth in most things; only that it is less friable; and even yields a little under the hammer. Mixt along with turmeric, in melted copper, it gives the metal a gold colour. It also serves to purify, and whiten tin; as lead does for gold, and silver. Some call it female antimony.

9°, *Rock-salt,* which usually contains some metallic part, along with a sulphur.

All these bodies contain a sulphur, which renders 'em soft, and their glebes less fix'd; and were it possible, as already observ'd of antimony, to make a separation of the sulphur, from the glebe; we should have perfect metals from each of 'em.

## SEMI-METALS, *of a Metal and Salt.*

*Vitriol.*

THe second class of semi-metals comprehends *vitriols,* properly so call'd.

*Vitriol* is described to be a salino-metallic, transparent glebe, dissolvable in water, and fusible, and calcinable by fire. It seems to derive its name *à vitri oleo,* from oil of glass; inasmuch, as when solid, it appears trans-

with silver and copper ore. When they have pick'd out the cobalt, and separated it from the common stone, they beat it to powder by a proper engine; carrying off all the lighter stuff with a stream of water. This powder, to separate the arsenic from it, they spread on a furnace; so that the fire, which is beneath, and behind it, is forced to pass its flame along over the powder, and thus takes with it the arsenic in form of a smoak; which passing out, at a low chimney, is received into a close brick channel, where the arsenic sticks, in form of a white or yellowish powder, whence it is taken once in six months, and melted into a mass.

The cobalt thus roasted, and ceasing to smoak, they take it out, and proceed to melt it, to make *smalt*: in order to which, it is mix'd with pot-ashes, and powder of flint-stones. After it has been five or six times in the melting-pot, it is found turn'd into a blue glass, which being pulveriz'd, is the smalt. *Philos. Transact.* N° 238.

* By pyrites is understood the mother, or marcasite of a metal: *i. e.* the matrix wherein it is form'd, and out of which, when arrived at maturity, the metal is procured: so that pyrites is only a cruder ore. It is differently denominated, according to the seed or stamen of metal it contains: *crysites,* if gold; *argyrites,* if silver; *chalcites,* if copper; *molybdites,* if lead; *siderites,* if iron. Bismuth, we have already observed, passes for the pyrites of tin.

† M. *Homberg,* maintains, with a good deal of probability, that zink is no other than a natural mixture, of two metals, *viz.* tin and iron. What gave him the first hint, was, that zink, by the burning-glass, yielded the same fumes as such a mixture. Hence he was led to substitute zink, in his operations, for the same; and he assures us, he always found the very same effects from one as t'other. *Mem. de l'Acad. An.* 1710.

parent

ſparent like glaſs; tho' when fuſed, it loſes that tranſparency, and changes into an opake, oily ſubſtance. Some call it a *metallic-ſalt*, as having the common properties of a ſalt, *viz.* to diſſolve in water, and fuſe by fire.

After the ſame manner, may all metals be converted, by acid ſpirits, into vitriol †: tho' 'tis very difficult to obtain vitriol of gold, or ſilver, by reaſon thoſe metals are not eaſily diſſolved by the ſpirit: But vitriols of iron and copper are eaſily had.

Native or foſſil vitriol †† is of two kinds, *viz. vitriol of iron*, or *Mars*, and *vitriol of copper*, or *Venus*. *Its kinds.*

The native vitriols are further reducible, with reſpect to their colour *, into four kinds, *viz. green* and *white*, whoſe metallic part, join'd with the ſalt, is iron: *roman* ||, which is blue; and *cyprian*, sky-colour'd; the metallick part of each of which is copper **.

† By cryſtallizing a ſolution of copper, in *Aqua fortis*, or ſpirit of nitre, you may obtain a good vitriol; which tho', by virtue of the compoſition, it has manifeſtly ſeveral qualities, not to be found in either of the ingredients alone; yet Mr. *Boyle* obſerves, there are ſtrong indications, that each ingredient retains its former nature, in the compound. *Scept. Chym.*

†† What we call native vitriol, is not ſtrictly ſo; at leaſt not in the ſame ſenſe with that of the antients. They had a vitriol call'd *chalcitis*, which came to perfection in the earth it ſelf: this they call'd by three different names, in its three ſeveral ſtages; *miſi* in the firſt; then *melanteria*; and laſtly *ſori*.

Our vitriol is none of it found in ſubſtance. 'Tis only a cryſtallization procured by art, from a ſort of ſulphurous marcaſite ordinarily found in copper mines, call'd alſo *pyrites* and *quis*.

Indeed Mr. *Boyle* aſſures us, he has ſometimes taken vitriol out of the mineral earth, where nature had, without any aſſiſtance of art, perfectly prepared it. *Scept. Chym.*

* This diverſity of colour ariſes from the difference wherein the ſalt, or acid, is receiv'd: in blue, the ſalt is join'd with copper; in green, with iron; in white, with calamine, or ſome ferruginous earth, mix'd with lead or tin. As to red vitriol, call'd *colcothar*, its colour is adventitious; and ariſes from a calcination the vitriol undergoes, either by art or ſome ſubterraneous fire.

|| *Roman vitriol* is made by expoſing the pyrites ſo long to the external air, that they calcine, and moulder into a greeniſh duſt or calx. This, they caſt into water, where being well diluted, and ſaturated, they proceed to evaporation by fire; which done, the vitriolic part ſhoots into cryſtals.

*Green vitriol*, call'd alſo *copperas*, is made, with us, in the copperas works at *Deptford*, in a ſomewhat different manner. The pyrites, or ſtones, call'd alſo gold ſtones, are found along the ſhores of *Eſſex*, *Hampſhire*, &c. The beſt are of a bright, ſhining, yellow colour. A heap of theſe ſtones, two foot thick, they lay on a bed, or baſon well ramm'd; where, in 5 or 6 years, by the action of the air and rain, they begin to diſſolve, and yield a liquor, which is receiv'd in the pits, and thence conveyed into a ciſtern under a boiling-houſe. In time, the ſtones turn into a ſort of vitriolic earth, which ſwells and ferments like leaven'd dough. The liquor, at length, being pump'd out of the ciſtern into a boiler, and a quantity of iron added thereto, in two or three days the boiling is compleated; care having been taken all along, to ſupply it with freſh quantities of iron, to reſtore the boiling, whenever it ſeem'd to abate: when boil'd, 'tis drawn off into a Cooler, where it is left 14 or 15 days to ſhoot.

** A drop or two of *Aqua fortis*, reſting a while on copper, the corpuſcles of the menſtruum join with thoſe of the metal; and this firſt produces an aſperity, and at length coagulates into minute grains, of a pale blue vitriol: and if on another part of the ſame ſurface, you apply a little ſtrong ſpirit of urine, a vitriol will ariſe, of a deeper and richer blue. *Boyle Mech. Prod. of Colours.*

We

We have ſeen a white vitriol from the Iſland of *Sumatra*, out of which the Inhabitants are ſaid, by boiling, to get pure gold: but the experiment is not eaſily tried; by reaſon the vitriol is ſo very ſcarce. When diſſolved in water, it affords a ſort of *Aurum potabile*.

*Its component parts.* Vitriol conſiſts of three ſeveral parts, *viz.* 1°, A metallic part, to which there is a ſulphur always adhering; 2°, A menſtruous acid; and 3°, Water or phlegm.

The metal is either iron or copper: The water gives the tranſparency; for as ſoon as that is evaporated, the vitriol becomes opake. While the water remains, the vitriol is fuſible; but that gone, its fluidity ceaſes, and it becomes a calx, which emits a fume, that corrodes all metals, and which, being collected, is call'd *ſpirit* or *oil of vitriol*.

This ſpirit, is ſcarce diſtinguiſhable from ſpirit of ſulphur *per campanam* *; and by pouring oil on the ſpirit, it becomes a real ſulphur; which, by corroding and diſſolving iron, or copper, becomes real vitriol again.

Now ſuch vitriols being only metals diſſolved and cryſtalliz'd in ſaline menſtruums, are frequently call'd by way of diſtinction, *metallic vitriols*, and *metallic ſalts*; of which there are as many kinds, as there are different metals, and menſtruums uſed.

## SEMI-METALS *of Metal and Earth.*

*Armenian ſtone.* THE third claſs of ſemi-metals, are thoſe conſiſting of a ſtony earth, or glebe, and a metal. Such are, 1°, The *lapis armenus*, or *armenian ſtone*; a mineral ſtone, or earth, wherein are diſcerned ſhining points or ſpangles, of a yellow colour; for which reaſon, it is alſo called *lapis ſtellatus*.

'Tis much the ſame as *lapis lazuli*; all the difference between 'em, if there be any, being only in the degree of maturity ||: they are both noxious to the body; and both appear to contain arſenic. Of *lapis lazuli* is made

* The principal ingredient in vitriol, is the acid ſalt, which is the ſame as in ſulphur, and alum: in ſulphur, this acid is united with a bituminous matter: in alum, with an abſorbent earth; and in vitriol, with a metalline part. *Nouv. Cour. de Chym.*

The metallic part is beſt ſeparated from the acid or ſaline part, by the affuſion of certain alcaline ſalts, in a liquid form, upon the ſolution of vitriol made in common water. *Boyle Scept. Chym.*

M. *Geoffroy* ſhews, that the mixture of any vitriolic ſalts, with an inflammable ſubſtance, will yield common brimſtone: and by the different compoſitions he has made of ſulphur, and particularly from oil of vitriol, and oil of turpentine; and by the analyſis of it, when thus prepared; he diſcover'd it to be nothing but the vitriolic ſalt, united with the combuſtible ſubſtance. *Mem. de l'Acad. An.* 1704.

|| The ſenſible characters that beſt diſtinguiſh 'em, are, that the lapis lazuli is harder, and vein'd with gold, which the armenus is not: add, that the blue of the latter partakes of a greenneſs, whereas that of the former is pure. They are both found in *Tyrol*, *Hungary*, &c. but the fineſt come from *Perſia* and the *Eaſt Indies*.

Some will have 'em the marcaſite of gold; as being often found in the mines of that metal: but it may be anſwer'd, that they are as frequently found in ſilver and copper mines.

that

that noble blue colour of the painters, call'd *ultra-marine* †; and of the lapis armenus, is made that other call'd *azure* ||.

2°, *Lapis hæmatites*, which is a ruddy mineral of a mean conſiſtence between ſtone and earth. It contains a noble metallic ſulphur, an earth, and an embrio or ſeed of iron. It is frequently found in iron mines; and is reputed in ſome meaſure the matrix thereof. *Schroder*, *Boyle*, &c. ſpeak of it as an earth out of which iron it ſelf is drawn by fire; and accordingly the antients call it *corpus martis*: But we can aſſure the contrary, and that the calx it reſolves into has no iron at all. However, it is of great uſe in medicine; and the preparations thereof are even preferr'd by *Sydenham* to thoſe from iron it ſelf. It is alſo uſed in poliſhing of metals **. *Lapis hæmatites*

3°, The *magnet* or *load-ſtone*, found about iron mines, and approaching very nearly to the nature of iron ſelf: tho' it is not altogether iron, as ſome have imagin'd. However, when diſſolved in *Aqua fortis*, it yields a little of that metal *†. *Load-ſtone.*

4°, *Lapis ætites*, or *Eagle ſtone*, which is pregnant, as it were, with another ſtone, heard to rattle in the middle of it. This too is of a ferruginous nature; and wonderfully commended by the antients for facilitating delivery ††. *Eagle-ſtone.*

† Ultra-marine is prepared by firſt calcining the *lapis* in an iron mortar, and then grinding it to an inpalpable powder on the ſtone. This done, they mix it up with a paſte, made of wax, pitch and oil; and waſh the paſte well in fair water to ſeparate the colouring part therefrom, which by this means precipitates to the bottom, in form of a fine powder. Laſtly, the water is poured off, and the powder, that remains, being dried, is the true ultra-marine.

|| The method of preparing it, is much the ſame as that of ultra-marine.

** *Pliny* recounts five ſpecies of this ſtone, *viz.* the *Ethiopic*, the *Andromedas* or black, the *Arabic*, the *Elalites* or *Miltites*, and the *Chiſtos*; beſides that call'd the *magnes hæmatites*, from its faculty of attracting iron. At preſent we know of nothing of this kind beſide the *blood-ſtone*, and *ruddle*.

*† The magnet is indued with very wonderful properties, and among the reſt, thoſe of attracting iron, and turning its poles toward thoſe of the world; and communicating the ſame properties to iron.

The antients diſtinguiſh'd five kinds, differing from each other both in colour and virtue, *viz.* the *Ethiopic*, *Magneſian*, *Bœotic*, *Alexandrian*, and *Natolian*. They had alſo a notion of a male and female magnet: but all the virtue they were appriz'd of in it, was the drawing of iron, and ſome ſmall medicinal power. What further diſcoveries the moderns have made herein, how happily they have applied it to facilitate the great buſineſs of navigation, and what fine phænomena it has afforded to the men of ſpeculation, is ſomewhat foreign to our preſent purpoſe. We ſhall only obſerve, that the fire, ruſt, moiſture, and long diſuſe, tend to weaken and deprive it of its force: Tho' Mr. *Boyle* gives us inſtances of ſome *Engliſh* load-ſtones, which retain'd their virtue after ignition. *See further in the Notes*, p. 93.

†† *Laur. Bauſchius* has an expreſs treatiſe on the *eagle-ſtone*; wherein he maintains, that it is not found in the neſts of eagles, as the antients imagin'd, but on the ſea-coaſts, in fields, and on mountains. Near *Treeves*, we are aſſured, that a man cannot dig a few feet under ground, without meeting with conſiderable beds or ſtrata of theſe ſtones, ſome of which have only one core or nucleus, others two, and others three. Moſt of them ſeem to conſiſt of two or three lays of a ſtony earth not unlike potters ware, eſpecially the laſt, which is the innermoſt. *Dict. de Trev.* Verb. *Ætites.*

Oker.

5°, *Oker*, or *ocker*, or *ockra*, a matter form'd of earth, and metal, subsided, or settled from spaw waters, and acidulæ: accordingly, 'tis observed, that spaw waters, dried up by the fire or air, always leave oker at bottom. Oker is also said to be found in iron mines, and places where iron is yet crude, and immature †. 'Tis added, that if you dissolve iron in oil of vitriol, oker, or a matter much like it, will be found at bottom.

GLASS makes the *fourth class of semi-metals*; and is defined a transparent body, fusible by fire, not dissolvable by water, nor malleable, and which hardens by cold*.

We have now gone thro' the natural history of fossils; and such as are disposed to furnish out their museums with collections of this kind, have here the several classes laid down, wherein every thing, according to its order, kind, &c. is to be disposed.

*Princi-*

† Oker is a metallic earth, found of various colours, red, yellow, &c. The best *Swedish* iron, we are told, is found in form of a mud or oker, at the bottom of lakes, and other stagnant waters. Mr. *Boyle* adds, that he has observed our *English* okers to be richer in iron than some ores of that metal: See the article *earths*. What further discovers this mixture of iron in oker, is, that by proper application, a piece of oker may be render'd magnetical like iron it self. *See the Notes, p. 93.*

* 'Tis controverted among naturalists to what class of bodies *glass* ought to be referr'd: *Agricola*, Lib. XII. *de re metall.* makes it a concrete juice: *Vin. Belluacensis*, Lib. XI. calls it a stone; and *Fallopius* reckons it among the *media mineralia* or semi-metals: but Dr. *Merret* observes, that the forementioned are all natural productions; whereas glass is factitious, a compound made by art, a production of the fire, and never found in the earth. To obviate this, *Fallopius* distinguishes between glass contain'd in its own mine, or its own stone; and true glass that is extracted from the same. Now, the latter, says he, is no more artificial, than a metal is, extracted from its mineral: and as to the former, he urges, that as metal, by having its existence in the ore, so glass by having it in the stone out of which it is educed, is natural. But this argumentation Dr. *Merret* overturns, by shewing that glass is never found in that form in any mine, but only the sand and stone whereof it is form'd: whereas metals are perfectly form'd by nature into certain species, in proper veins, tho' frequently in such small parcels, that they lie hid, till the fire has collected 'em together, by separating from 'em the other matters wherewith they were mix'd. Accordingly, fire only produces metals by its faculty of separating heterogeneous, and congregating homogeneous bodies; whereas it produces glass by uniting, and mixing heterogeneous matters, *viz.* salt and sand, into one. *Fallopius*, indeed, denies this, and pleads, that 'tis false to say that glass is at all made of ashes: the ashes are only added instead of the nitre, used among the antients, the better to extract the glass out of the substance of the stone: But this is easily refuted: for if the glass were procured from the stone alone, the weight of the metal must be less than that of the stones; whereas in reality it far surpasses; 100 weight of sand yielding above 150 *lib.* of glass. Add, that the salts made use of, are of the most fixed kind; which therefore, we cannot suppose to be carried off by the fire: and that in the coarser glasses, which corrode by the air, one may discern, nay pick out pieces of salt, discovering themselves to be such by their taste.

Dr. *Merret* gives us a precise and accurate enumeration of the several characters, or properties of glass; the principal whereof are, that it fuses in a vehement fire; when fused, is tenacious, and cleaves to iron; does not consume or waste in the fire, and is the last effect thereof; is ductile and fashionable into any form, while red hot, but not malleable; friable when cold; diapha-

## *Principles of* FOSSILS.

FRom what has been hitherto delivered, we deduce it, as a corollary, that all fossils consist, 1°, Of *mercury*, as the base of many of 'em. 2°, Of a subtile *sulphur*, the coagulator or fixer of the mercury: for even the antients always distinguish'd two kinds of sulphur, the one volatile, and combustible; and the other, which alone we have here regard to, perfectly fix'd; as being in effect a sort of concentrated fire it self; 3°, Of *salt*; and 4o, Of *earth*.

All

diaphanous either hot or cold; flexible and elastic; disunited, and broke by cold and moisture, and especially by saline liquors; is only cut by a diamond or emery; does not let acid juices, or any other thing extract either colour, taste, or any other quality from it; does not wear, by the longest use, nor will any liquor make it musty, change its colour, or rust; it softens metals, and renders 'em fusible; receives all metallic colours, both externally and internally; will not calcine; may be cemented, like stones and metals.

### *Making of Glass.*

The materials whereof glass is made, we have already hinted to be *salt* and *sand*, or stones. The *salt* here used, is procured from a sort of ashes brought from the *Levant* call'd *polverine* or *rochetta*; which ashes are those of a sort of water-plant, call'd *kali*, of the species of that found in some parts of *England*, call'd *frog-grass*, or *crab-grass*; cut down in summer, dried in the sun and burnt in heaps, either on the ground, or on iron grates; the ashes falling into a pit, grow into a hard mass or stone, fit for use.

To extract the *salt*, these ashes, or *polverine*, are powder'd, and sifted; then put into boiling water, and there kept till $\frac{1}{3}$ of the water, be consumed; the whole being stirr'd up from time to time, that the ashes may incorporate with the fluid, and all its salts be extracted: then the vessel is fill'd up with new water, and boil'd over again, till $\frac{1}{2}$ be consumed; what remains is a sort of lee, strongly impregnated with salt. This lee, boil'd over again in fresh coppers, thickens, and in about 24 hours shoots its salt; which is to be laded out, as it shoots, into earthen pans, and thence into wooden vats to drain and dry. This done it is grossly pounded, and thus put in a sort of oven, call'd *calcar*, to dry. It may be added, that there are other plants beside kali which yield a salt fit for glass, *e. gr.* alga, or sea-wrack, the common way-thistle, bramble, hops, wormwood, woad, tobacco, fern, and the whole leguminous tribe, as pease, beans, &c.

The *sand*, or *stones* call'd by the artists *Tarso*, is the second ingredient in glass; and that which gives it the body and firmness. These stones, *Agricola* observes, must be such as will fuse; and of these, such as are white and transparent, are the best: so that crystals challenge the precedency of all others. At *Venice* they chiefly use a sort of pebble, found in the river *Tesino*, resembling white marble, and called *Cuogolo*: indeed *Anto. Neri* assures us, that all stones which will strike fire with a steel, are fit to vitrify: but Dr. *Merret* shews, that there are some exceptions from this rule. Flints are admirable, and when calcined, powdered, and searced, make a pure white crystalline metal; But the expence of preparing 'em, makes the masters of our glass-houses sparing of their use. Where proper stones cannot be so conveniently had, *sand* is used; which is to be white, and small, and well wash'd e'er it be applied: such is usually found in the mouths and sides of rivers. Our glass-houses are furnished with a fine sand, for crystal, from *Maidstone*, the same with that used for sand-boxes, and in scouring; and with a coarser, for green-glass, from *Woolwich*.

For *crystal glass*, to 200 *lib.* of *tarso*, pounded fine, they put 130 of salt of *polverine*, mix 'em together, and put 'em into the *calcar*, a sort of oven or reverbera-

 tory

All which are not found in all foſſils; metals, *e. gr.* we have already ſhewn to conſiſt of only the two firſt principles: and ſeveral others, only of the three laſt.

Whether *water*, the univerſal wine of the antients, which all bodies drink, and whereby alone they are ſuppoſed to grow and increaſe, be to be deem'd a principle; will admit of ſome doubt: Sir *Iſ. Newton* defines it

tory furnace, which is firſt well heated. Here they remain, baking, frying, and calcining for 5 hours; during which the workman keeps mixing 'em with a rake, to make 'em incorporate: when taken out, the mixture is call'd *frit* or *bollito*.

Note, there are three kinds of *frit*: that here deſcribed is cryſtal frit: the ſecond, or ordinary frit, for the common white, or cryſtalline metal, is made of the bare aſhes of polverine, without extracting the ſalt from 'em. The third, for green glaſs, is made of common aſhes, without any preparation, and a hard ſand abovemention'd.

It may be further obſerv'd, that glaſs might be made by immediately melting the materials, without thus calcining, and making 'em into frit; but the operation would be much longer, and more tedious.

Now, to proceed to the *operation of making the glaſs it ſelf*; they take of this frit, and ſet it in melting-pots in the working furnace; adding, in each pot, a proper quantity of a blackiſh ſtone, not unlike a load-ſtone, and call'd *manganeſe*, which ſerves to purge off that greeniſh caſt natural to all glaſs, and to make it clearer, and more azure. While the whole is in fuſion, the workman, here call'd the *conciator*, in the green-glaſs-houſes the *founder*, mixes the metal well together, with his *ſquare*; and with a ladle skims off the ſand, over which is a whitiſh ſalt continually caſt up from the metal, and ſwimming on its ſurface; which is always in the greater quantity, as the polverine was weaker; and which, unleſs well purg'd off, would make the glaſs brittle, and unfit for working.

When the vitrefaction is compleated, and the metal found ſufficiently clear, and fine; they proceed to form it into the works required: in order to this, the operator dips a hollow iron into the melting pot, turns it about, and takes out enough for the veſſel or work it is intended for; the metal ſticking to the iron, like ſome glutinous or viſcid juice. While 'tis yet red hot, he rolls it to and fro, on a marble, to unite its parts more firmly: then gently blowing into the iron, he raiſes or ſwells the metal, juſt as in blowing into a bladder. This blowing he repeats again and again, till he has attained the deſtin'd bulk; then whirling it about his head, he lengthens, and cools the glaſs; and, if the deſign require it, moulds it in the ſtamp-irons, and flats the bottom, by preſſing it on the marble: and thus delivers it to the maſter workman, who breaking off the collet, by which it adhered to the blowing-iron, proceeds, as occaſion requires, to faſhion it further; *e. gr.* if it be for a drinking glaſs, with his *ponteglo* he ſticks the glaſs, and ſcalds it; with his *paſſago* makes the bowl; with his *procello* widens and makes it hollower; then with his ſheers cuts off what is ſuperfluous. Thus with *blowing*, *preſſing*, *ſcalding*, (which are to be repeated as oft as the glaſs cools,) *amplifying*, *cutting*, &c. the work is brought to the form intended; and, if need be, feet and handles are faſtened on; and rigarines and marblings wrought.

As faſt as the maſter finiſhes them, another takes 'em up with an iron fork, and places 'em in a *tower*, over the melting furnace, to *anneal*: into this tower, there is a hole, by which the heat and flame are received from the furnace; and after the glaſſes have ſtood here ſome time, they are put into iron pans call'd *fraches*, which by degrees are drawn, by the *ſarole-man*, further off, along an appendage of the tower called the *leer*, 5 or 6 yards along, that they may cool by degrees: when they are arrived at the end of the leer, they are quite cold, and thus taken out, fit for uſe. *Antonio Neri de Arte Vitraria*, and Dr. *Merret's Notes on the ſame*.

an

*an insipid salt* ; but with that great author's leave, water's being a dissolvent of salt seems to disqualify it for being a salt it self : we know of no salt in nature that dissolves any other salt.

Others call it the *chaos* of all things, and 'tis certainly the remote matter of all fossils ; and may therefore be consider'd as constituting a peculiar class of body. See the Chapter *of water*, as an element or instrument.

Of all these principles, the *sulphur* is the only active, and vital one ; and that whereon all life and motion depends ; for mercury, *e. gr.* is inert, and never acts, unless when acted on by sulphur or fire : and salts are never dissolved, but by fire alone ; nor does water act but by heat ; without which it would be a fixed mass, or *ice* : and as to earth, no body doubts it merely inert, and inactive. So that all the activity in the fossil or mineral kingdom consists in the sulphur alone : and hence some of the later chymists have denominated sulphur, *active*, *masculine*, &c. with regard to which the rest are inactive, torpid, feminine, *&c.* See further in the chapter of *the operations of chemistry*, and that of *fire*, *water*, &c.

We now proceed to vegetables.

# Of VEGETABLES;

## OR, THE

## VEGETABLE KINGDOM.

*Vegetables defined.*

A *Vegetable is a body generated of the earth, or of ſomething ariſing of the earth, to which it adheres, or is connected by parts call'd roots, thro' which it receives the matter of its nouriſhment, and increaſe ; and conſiſts of juices, and veſſels, ſenſibly diſtinct from each other* : or, a vegetable *is an organical body, compoſed of veſſels, and juices every where diſtinguiſhable from each other; to which body grow roots, or parts whereby it adheres to ſome other body, from which it derives the matter of its life, and growth.*

*Diſtinguiſh'd from foſſils and animals.*

This definition furniſhes a juſt and adequate idea of a vegetable : for by its *conſiſting of veſſels and juices*, it is diſtinguiſhed from a foſſil ; and by its *adhering to another body, and deriving its nouriſhment therefrom*, it is diſtinguiſh'd from an animal *.

A vegetable is defined *an organical body*, becauſe conſiſting of different parts, which jointly concur to the exerciſe of the ſame function : *adhering by ſome of its parts to another body* ; for we know of no plant that is abſolutely vague and fluctuating, but has ſtill a body it adheres to : tho' that body may be various, *e. gr. earth*, as in our common plants ; *ſtone*, as in rock-plants ; *water*, as in the ſea-plants ; and *air*, as in ſome mucilages.

* Few authors but obſerve the near analogy between the vegetable and animal oeconomy and ſtructure. M. *Reneaume*, from a ſurvey of plants, concludes, 1°, That the *root* in plants, does the office of the parts contained in the belly of animals deſtined for nutrition ; it being this chiefly that prepares, digeſts, alters, and changes the food into a nutritious juice, to be afterwards diſtributed to all parts. 2°, That the *trunk*, and *branches* of trees, bear ſome relation to the exterior members or limbs of an animal, which it may indeed ſubſiſt without, tho' their rotting, and mortification, does frequently occaſion a total deſtruction thereof. 3°, That 'tis with good reaſon that countrymen, in pruning, and lopping trees which they would have grow again, cover the wounds, and the remains of the ſtumps, with earth or clay, to prevent an *extravaſation*, which would drain 'em of all their vital moiſture. And hence, likewiſe, it is, that when the branch of a tree is broke, without the bark's being entirely ſeparated, if the pieces be ſet again, and the *fracture* tied with a bandage, capable of retaining the ſap, and excluding the acceſs of the air, the branch will heal again, a *callus* be form'd, &c. juſt as in a fractur'd bone. *Mem. de l'Acad. An.* 1707.

A

*Floating plants.* As to thoſe few plants which appear to float with the water, their manner of growth is ſomewhat anomalous *. M. *Tournefort* has ſhewn that all plants do not ariſe, ſtrictly, from ſeeds, but that ſome inſtead of ſemen, depoſite, or let fall a little drop of juice, which ſinking in the water, by its gravity, reaches the bottom, or ſome rock, *&c.* in its way; to which it ſticks, ſtrikes root, and ſhoots into branches; ſuch is the origin of *coral* †, which by diſtillation yields a volatile ſalt.

*Situation of the Root.* Add, that the root of a plant may have any ſituation at pleaſure, with reſpect to the body thereof; nor needs it either be loweſt or higheſt, *&c.* Accordingly in aloes, coral, moſſes, fungus's, *&c.* the root is frequently uppermoſt, and its growth downward ‖.

*Vaſcular part of plants.* The veſſels, or containing parts of vegetables, conſiſt of mere earth, bound, or connected together by oil, as a gluten; which being exhauſted by fire, air, age, or the like, the plant moulders, or returns again into its earth, or duſt: thus in vegetables burnt by the intenſeſt fire, the earth

* There are ſome ſpecies of ſea-muſhrooms, particularly the *neptune's-cap*, which are not found to adhere to any body: but M. *Tournefort* obſerves, they have been ſometimes obſerv'd with a little pedicle, which might have ſuſtained them. And hence he infers, that they originally grew to the bottom, and had their generation like the reſt. He adds, however, that when they have loſt their pedicle, 'tis probable they are fed by ſome juice, which the ſea water lets inſinuate thro' the pores of their ſurface. *Mem. de l'Acad. An.* 1700.

† Coral has been ſuſpected by the naturaliſts of all ages for a ſea-plant; but the moderns have demonſtrated it ſuch; and even diſcovered its flowers and ſeeds. That illuſtrious naturaliſt the Count *de Marſigli*, having long doubted the vegetable nature of coral, was at length convinced by the following experiment: having ſteep'd ſome coral, freſh gather'd, in ſea-water; he perceived, in a ſhort time, that the little ruddy tubercles which appeared on the ſurface of its bark, began gradually to unfold; and at length opened into white flowers, in the form of ſtars of eight points, which were ſuſtain'd by a little calx divided in like manner into eight parts. Upon taking the coral out of water, the flowers immediately cloſed, and return'd into red tubercles as before; which tubercles being cloſely ſqueezed, yielded a ſort of milky juice. And upon returning the coral into the water, as before, the tubercles, in an hours time, opened, or flower'd a-freſh: And this was continu'd for 6 or 8 days, when the buds or tubercles ceas'd to blow any more. In 10 or 12 days they became detach'd from the coral, and ſunk to the bottom, in form of little yellow balls. Theſe tubercles, then, according to the analogy of plants, ſhould be the flowers of coral; and the milky viſcid juice, contain'd therein, the ſemen; accordingly 'tis held, that when this juice falls on a properly diſpoſed ſubject, or nidus, a new coral ariſes therefrom.

Add, that the analyſis of coral, anſwers preciſely to that of other ſea-plants, all of 'em affording a volatile urinous ſalt, and a thick blackiſh, fetid oil. *Mem. de l'Acad. An.* 1708.

There are corals of divers colours; the moſt uſual, and valuable, are red, and white; others are feuillemort, carnation, green, yellow, aſh-colour'd, *&c. Journ. des Scavans, An.* 1710.

‖ The vaſcular ſtructure of vegetables is rendered very apparent by an experiment of Mr. *Willoughby*; cutting off ſome pretty big branches of birch, and making a ſort of baſon or reſervoir, on the end thereof with ſoft wax; upon filling this with water, and holding the branch upright, the water, in a few minutes, ſunk into the veſſels of the wood, and running quite thro' the length, dropt out of the end conſiderably faſt; continuing ſo to do, ſo long as water was pour'd on. The ſame ſucceeds in ſycamore, walnut, *&c.* tho' the flux here is not ſo copious. *Phil. Tranſact.* N° 70.

*Indissoluble by fire.* earth or matter of vessels is left entire, and undissoluble by its utmost force; and consequently, the matter thereof is neither water, nor air, nor salt, nor sulphur, but earth alone.

The *root* or part, whereby vegetables are connected to their matrix, and by which they receive their nutricious juice, consists of an infinite number of *vasa absorbentia*, which being dispers'd thro' the interstices of the earth, attract and imbibe the juices of the same *; consequently every thing in the earth, that is dissoluble in water, is liable to be imbibed; as air, salt, oil, fumes of minerals, metal, *&c.* and of these do plants really consist.

*Absorbent vessels of plants.*

These juices are drawn from the earth, very crude; but by the structure and fabric of the plant, and the various vessels they are strained thro', become changed, further elaborated, secreted and assimilated to the substance of the plant.

The motion of the nutricious juices of vegetables is produced, much like that of blood in animals, by the action of the air; in effect, there is something equivalent to respiration throughout the whole plant.

The discovery of this we owe to the admirable *Malpighi*, who first observ'd that vegetables consist of two series's or orders of vessels; 1°, Such as receive and convey the alimental juices, answering to the *arteries*, *lacteals*, *veins*, &c. of animals. 2°, *Tracheæ* or *air-vessels*, which are long hollow pipes, wherein air is continually received and expelled, *i. e.* inspired and expired; within which *Tracheæ*, he shews, all the former series's of vessels are contained.

*Arteries, &c.*

*Tracheæ.*

Hence it follows, that the heat of the year, nay, of a day, of a single hour, or minute, must have an effect on the air included in these *Tracheæ*, *i. e.* must

* The principle, whereby the root imbibes its food, is somewhat controverted: some will have it effected by means of the pressure of the atmosphere, in the same manner as water is raised in pumps: But this is precarious; as being founded on the supposition that the absorbent tubercles are void of air: beside that the atmosphere could only raise the juice 32 foot high, whereas there are trees much higher. Others have recourse to the principle of attraction, and suppose the power that raises the sap in vegetables, to be the same with that whereby water ascends in capillary tubes, or in heaps of sand, ashes, or the like: But neither will this alone suffice to raise water to the tops of trees. One would suspect, therefore, that the first reception of the food, and its propagation, thro' the body, were effected by different means; which is confirm'd by the analogy of animals.

Some of our ablest naturalists hold water the only nutritious matter of vegetables: *Helmont* and Mr. *Boyle* give us some experiments which very much favour this doctrine. The first, weighing a quantity of earth, and planting a willow therein, which he water'd with rain, or distill'd water only; in 5 years time raised it from 5 pound weight, to 169 pounds 3 ounces; and this without any greater diminution of earth than 2 ounces: and Mr. *Boyle* found the like experiment to succeed with squash seed. Dr. *Woodward*, on the other hand, has some curious experiments, which seem to overturn this notion, and to prove that mere elementary water is not proper food for vegetables; the water, according to him, only the vehicle of the alimentary matter, the earth contain'd therein, supplying all the vegetation. *See the Article of Water.*

rarify

rarify it, and conſequently dilate the *Tracheæ*: whence ariſes a perpetual ſpring or ſource of action to promote the circulation in plants.

*Effect of heat thereon.* For by the expanſion of the *Tracheæ*, the veſſels containing the juices, are preſſed; and by that means the juice contained is continually propel'd, and ſo accelerated. By which propulſion, the juice is continually comminuted, and render'd more and more ſubtile, and ſo enabled to enter veſſels ſtill finer and finer *; the thickeſt part of it being, at the ſame time, ſecreted, and depoſited into the lateral cells or *loculi* of the bark, to defend the plant from cold, and other external injuries.

*Circulation of the ſap.* The juice having thus gone its ſtage from the root to the remote branches, and even the flower; and having, in every part of its progreſs, depoſited ſomething, both for aliment, and defence; what is redundant, paſſes out into the bark, the veſſels whereof are inoſculated with thoſe wherein the ſap mounted; and thro' theſe it redeſcends to the root, and thence to the earth again. And thus a circulation is effected †.

Thus

* But there may ſeem ſomewhat of difficulty behind; *viz.* why the preſſure and contraction of the air, in the *Tracheæ*, ſhould determine the juice upwards, rather than in any other direction? To which it may be anſwer'd, that the heat being greater toward the root, than the top; the air is more rarified, and conſequently the compreſſion the juices undergo, is greater, in the former place than the latter; ſo that they muſt be determined that way, for the ſame reaſon as the moiſture of green wood, when burning, exudes thro' the part furtheſt from the fire.

† The notion of the ſap's circulating, was entertain'd by ſeveral authors, much about the ſame time; without any communication from one to another; particularly M. *Major*, a phyſician of *Hambourg*, M. *Perrault*, *Mariotte*, and *Malpighi*. It has met, however, with ſome conſiderable oppoſers; particularly the excellent M. *Dodart*, who could never be reconciled to it.

One of the great arguments for it, is, that the ſame experiments of ligature and inciſion which evince a circulation of the blood in animals, ſucceed, in the like manner, in plants; particularly in ſuch as abound with ſap, as the great tithymale, milk-thiſtle, &c. For a metalline girt being here fix'd tight round the ſtem; the part above it is found to ſwell very conſiderably, and that below it a little. Whence it appears, that there is a juice aſcending from the root, and likewiſe another deſcending from the branches; and that the latter is thicker than the former; which quadrates exactly with the common ſyſtem; the juice being ſuppoſed to ariſe in capillary veſſels, in form of a ſubtle vapour, which condenſed in the extremes of the plant, by the neighbourhood of the cold air, turns back, in form of a liquor, thro' the more patent pipes of the inner bark.

M. *Dodart*, inſtead of the ſame juice's going and returning; contends for two ſeveral juices; the one, imbibed from the ſoil, digeſted in the root, and thence tranſmitted to the extremes of the branches, for the nouriſhing of the plant; the other, receiv'd from the moiſture of the air, in at the extremities of the branches: ſo that the aſcending and deſcending juices are not the ſame. One of his chief arguments, is, that if two trees of the ſame kind be tranſplanted in one day, after firſt cutting off their roots, and branches; and if after they have taken root again, ſome of the new ſhoots, put forth each year, be cut off one of them, it will not thrive half ſo well, notwithſtanding its root and trunk's being entire, as the other. This he conceives to be a proof of the plant's deriving nouriſhment by the branches; and concludes it to be of an aerial nature, becauſe form'd of the moiſture of the air, dew, &c. whereas that imbibed from the ſoil, is terreſtrial, &c. *Hiſt. de l'Acad. Roy. An.* 1709.



But

*Functions of night and day.* Thus is every vegetable acted on by heat or cold, during the day-time; especially while the sun's force is considerable; the sap-vessels squeezed, and pressed, and the sap protruded, and raised, and at length evacuated, and the vessels exhausted: And in the night again, the same *Tracheæ* being contracted by the cold of the air, the other vessels are eased, and relaxed, and so disposed to receive fresh food for the next day's digestion, and excretion. And thus plants may be said to eat and drink in the night-time *.

The

But what seems to be an *experimentum crucis*, and to decide the controversy in favour of a circulation, is the following experiment of the reverend Mr. *Laurence*: On a branch of plain jessamin, whose stem spreads into two or three branches, inoculate a bud of the yellow-striped jessamin; and as the tree comes to shoot, the following spring, some of the leaves will be found tinged here and there with yellow; and this even on the other branches not inoculated; till, by degrees, the whole tree, even the very wood of the young shoots, appear all variegated, or striped green and yellow.

* What course the juice takes after it is imbibed by the roots, is not very clear; the vessels that take it up to convey it thro' the plant, are too fine to be traced: and hence it has been controverted, whether it is by the *bark*, or the *pith*, or the *woody* part, that the plant is fed.

Some contend for the *wood*, which they observe to consist of slender capillary tubes, running parallel to each other from the root up the trunk, proper to receive in a fine vapour; in the ascent whereof, the fibres become opened, and their substance increased. And thus it is, that the trunks of trees increase in circumference, by *ingestion*.

The more common opinion is for the *bark*; the juice raised by the capillaries of the wood, is here supposed to descend by the larger fibres placed in the inmost part of the bark, immediately over the wood; in which descent, the sap, now sufficiently prepared, adds a part of its substance to the contiguous wood; and thus increases by *apposition*. And hence it is, that hollow, carious trees, which have neither pith, nor wood, except just enough to sustain the bark, do grow, and bear.

What confirms this, is an observation of Dr. *Tonge*, communicated to him by an eminent planter in *Glocestershire*; *viz.* that by binding a tree round about very closely, and strongly, with cords, so as to intercept what rises betwixt the bark and the wood, the blossoming, and bearing of the tree is retarded: And by such means, in some years, when the open weather bringing on too early a spring, endangers the destruction of the blossoms, &c. he has often prevented a scarcity of forward fruits, which are usually nipped by the late frosts. *Phil. Transact.* N° 68.

Add, that in the journals of the royal society, Dr. *Beal* assures us from his own experiment, that if a circle be drawn round a common *English* tree by incision to the solid timber; how thin soever the knife be, and tho' nothing at all be taken away; the tree will die from that part upwards: only the part below the cleft will grow on, and prosper, notwithstanding the incision. He adds, that he has seen some old huge ashes, which had been bared of their bark by the deer, from the root to the height of four feet quite round; and yet have continued their growth for many years; and some bark, which was left in some few places, no broader than an hand, had a fresh verdure more lovely than any other part of the tree. *Philos. Transact.* N° 46.

To this others object, that there have been trees known to grow, and put forth leaves and flowers for several years, without any bark; particularly that elm in the *Tuilleries*, whereof an account was given to the royal academy, by Monsieur *Parent*. Add, that the plantane and cork-tree cast their barks, and get new ones, as serpents cast their skins; and 'tis hard to conceive how the bark, during such transition, should contribute to the support of the plant,

The humour or ſap of a plant, then, is a juice furniſhed by the earth, and changed into the plant; conſiſting of ſome foſſil parts, other parts derived from the air, and rain; and others from putrified animals, plants, *&c.* conſequently, in vegetables are contained all kind of ſalts, oil, water, earth; and, probably, all kinds of metals too, inaſmuch as the aſhes of vegetables always yield ſomewhat which the load-ſtone attracts. *Ingredients of the ſap.*

This

plant. Beſide, in ſome plants, as the vine, elder, *&c.* the bark is very inconſiderable, but the pith very copious; which ſhould ſeem to intimate, that they are fed by the latter rather than the former. And it is further obſervable, that in proportion as they grow old, the pith becomes fibrous, and woody; which ſhews, that the pith is diſpoſed by nature to form woody fibres; and therefore may be proper to furniſh wood with its nutritious juice.

Laſtly, it is obſerved, that if you cut off a ring of bark around a tree, three or four inches broad, parallel to the horizon; and thus lay the wood quite bare, ſo that the tree cannot receive any nouriſhment by the bark; yet will it not loſe its leaves; nay, it will bear flowers and fruit the ſame year, and this double its uſual crop: tho' in the ſucceeding winter, all the branches above the inciſion will die. Hence, M. *Parent* argues, that the juices which produce and nouriſh the leaves, the flowers, and fruit, do not aſcend by the bark, but by the *pith*; but thoſe which nouriſh the wood and bark, by the *bark*: and that the quantity of the juice which ſhould naturally have paſs'd by the pith, having been augmented with that which ſhould have paſſed by the bark, is the cauſe of the extraordinary produce of fruits and flowers. In effect, ſays M. *Fontenelle*, the pith of plants, like the *medulla* in animals, is a collection of an immenſe number of little veſicles, which ſeem deſtin'd to filtre and elaborate a finer juice than ſhould ſeem neceſſary for the nutrition of mere wood. *Hiſt. de l'Acad. An.* 1709.

In anſwer to all this, the retainers to the *bark* alledge, that the parts of a tree disjoined from their whole, may take with them a ſtock of nutritious juice ſufficient to make them vegetate. Thus, the branches of elder, willow, *&c.* cut from the ſtock, will ſhoot forth leaves, twigs, *&c.* without being ever put in the ground; and pieces of wood, half dry, have been known to do the ſame: which muſt be owing to ſome remaining juice agitated and ſubtilized to a certain degree by the warmth and action of the air. And if parts thus cut off may vegetate; much more may thoſe which ſtill adhere to the tree, which can ſcarce ever be entirely deprived of new juices; ſince, tho' the bark ſhould not furniſh them any, yet they will receive ſome from the *blea*, or that part of the wood which was laſt form'd, and has not altogether loſt its cortical nature. This accounts for the phenomena of the elm in the *Tuilleries*, the aſh's of Dr. *Tonge*, and the olive-trees of M. *Magnol*; excepting that in this laſt inſtance, the vegetation is more abundant, after taking away the bark, than before; which gives a new difficulty.

To ſolve this, M. *Reneaume* obſerves, that the buds out of which flowers and fruits ariſe, are form'd at the ſame time as the young branches whereon they grow; for old wood never bears any: that the buttons wherein theſe fruit-buds are contained, are eaſily diſtinguiſhed from the buds that yield nothing but wood: that theſe fruit-buds require nothing but to be expanded, which ſometimes does not happen, in perfection, till the ſecond year: that it is eaſily poſſible this expanſion ſhould not ſucceed ſo well, when, beſide a competent ſtock of juice, in reſerve, new juices are brought by the bark, in too great plenty to be ſufficiently attenuated, and ſubtilized, for entring the minute veſicles of the forming part. Thus, by cutting off the communication of new juices by removing ſome of the bark, the juice is diſpoſed to inſinuate more readily into the little veſſels; and thus to give riſe to a greater number of flowers and fruits.

As to the elms of *Luxembourg*, M. *Reneaume* examined them himſelf, and found they were not ſo naked, but that there



were

*Gradual progreſs and preparation of the ſap.* This juice enters the plant in form of a fine and ſubtile water; which, the nearer it is to the *root*, the more it retains of its proper nature; and the further from the root, the more action it has ſuſtained, and the nearer it approaches to the nature of the vegetable.

Conſequently, when the juice enters the root (the bark whereof is furniſhed with excretory veſſels, fitted to diſcharge the excrementitious part) it is earthy, watery, poor, acid, and ſcarce oleaginous at all.

*In the trunk and branches.* In the *trunk* and *branches* it is further prepared, tho' it ſtill continues acid; as we ſee by the tapping or perforating of a tree in the month of *February*, when it diſtils a watery juice apparently acid.

*In the buds.* The juice being hence carried to the *gems* or *buds*, is more concocted; *In the leaves.* and here having unfolded the leaves, theſe come to ſerve as lungs for the circulation, and further preparation of the juice.

For thoſe tender leaves being expoſed to the alternate action of heat and cold, moiſt nights, and hot ſcorching days, are alternately expanded and contracted; and the more, on account of their reticular texture.

By ſuch means is the juice ſtill further alter'd, and digeſted; as *In the petala.* it is further yet, in the *petala* or leaves of the flowers, which tranſmit the juice, now brought to a further ſubtility, to the *ſtamina*: Theſe

were ſome remains of the inner rind or *blea*, whereby the juice might mount: And the ſame, doubtleſs, was the caſe of the aſhes mention'd by Dr. *Tonge*. Add, that M. *Maraldi* obſerved to the royal academy, that a ſhoot of a plum-tree having been broke, ſo as only to hang by a piece of bark; yet, upon raiſing and ſetting the fractured parts, it produced wood, flowers, and fruit.

From the ſame obſervation of the elm of *Luxembourg*, M. *Reneaume* even draws a concluſion in behalf of his ſyſtem, *viz.* that it is the bark forms the blea or bleak; and that as the blea is the wood laſt form'd, all the wood comes from the bark.

The bark, *liber*, is to be conceived as conſiſting of a number of cylindric and concentric ſurfaces, whoſe texture is reticular, and in ſome trees apparently extenſible every way, by reaſon the fibres thereof are ſoft and flexible. While in this condition, they are either hollow, and ſo real canals; or, if they be ſolid, their interſtices are canals. The nutritious juice which they are continually receiving, and which, part of it, is detain'd in them, makes them grow both in length and thickneſs, ſtrengthens, and brings them nearer each other. Perhaps the longitudinal fibres may grow the faſteſt. By ſuch means, the texture, which before was reticular, becomes an aſſemblage of ſtrait fibres, ranged vertically, and parallel one behind another; *i. e.* it becomes a new woody ſubſtance, under the name of *blea*.

While the *blea* remains, any thing ſoft, and retains ſomewhat of the nature of a bark; it may maintain a feeble vegetation: but when it is grown abſolutely hard and woody, it can no longer contribute thereto. The vegetation of young branches is the moſt lively and vigorous, and the only one that goes as far as the flowers and fruits, by reaſon they are little elſe but bark.

For the *pith*; as the woody ſubſtance of the trunk becomes more woody, the pith is compreſſed and ſtraiten'd, to ſuch degree, that in ſome trees it quite diſappears: Whence it appears, that its office in vegetation is not very important, ſince its uſe is not perpetual. By its ſpongeous ſtructure, it ſhould ſeem fitted to receive any ſuperfluous moiſture tranſuding thro' the pores of the woody fibres: And if by the exceſs of ſuch moiſture, or the like cauſe, it corrupt and rot, as frequently happens in elms, the tree does not grow the worſe for it. A convincing proof, it is of no great uſe. See the *Hiſt. de l'Acad. R. des Sciences*, *An.* 1711.

com-

communicate it to the *farina*, or duſt in the *apices*, which is, as it were, the male ſeed of the plant; where having undergone a further maturation, it is ſhed into the *piſtil*, which performs the office of a womb or *uterus*: and thus having acquired its laſt perfection, it gives riſe to a new fruit or plant *. *In the* ſtamina, farina, &c. *Generation of plants.*

*Six*

* The generation of plants bears a near analogy to that of ſome animals, particularly ſuch as want local motion; as muſcles, and other immoveable ſhell-fiſh, which are hermaphrodites, and have the genital organs of either ſex.

The flower, for all its finery, has been allow'd for the *pudendum* of a plant: but the deſign of ſo much mechaniſm, and ſo many parts, was but little underſtood: To inſtance in a *tulip*; its flower conſiſts of ſix leaves, in the middle whereof ariſes the piſtil, and around that are ranged a number of little threads, which terminate a-top in little bunches replete with a fine powder. This is the general ſtructure of flowers; tho' we find it diverſify'd a thouſand ways, ſome ſpecies appearing to want one part, and ſome another, and ſome even the whole flower.

The duſt contained in the *apices*, M. *Tournefort* took to be only a ſort of excrement, remaining of the food of the fruit; and the *ſtamina* to be no other than excretory ducts. But M. *Morland*, M. *Geoffroy*, and other of the later authors, are agreed on aſſigning them nobler uſes. On their principle, the *ſtamina*, with the *apices* and *farina*, make the male part of the plant; and the *piſtil* the female.

At the bottom of the piſtil of the lilly, Mr. *Bradley* obſerves a veſſel, which he denominates in a particular manner the *uterus* or womb: it contains three ovaries, which are fill'd with little eggs, or rudiments of fruit, like thoſe found in the *ovaria* of animals; and which, he adds, always decay, and come to nothing, unleſs impregnated with the *farina* of the ſame plant, or ſome other of the ſame kind. The *ſtamina*, according to him, ſerve for the conveyance, or perhaps the ſecretion of the male ſperm, to be perfected in the *apices*, which anſwer to the *veſiculæ ſeminales*; whence, being emitted into the orifice of the piſtil, it is either conveyed thence into the utricle, to fecundify the female *ova*; or it is lodg'd in the piſtil, and by ſome magnetic power draws the nouriſhment from other parts of the plant into the embryo's of the fruit; and thus makes them ſwell, grow, &c.

Accordingly, the diſpoſition of the piſtil, and *apices* about it, is always ſuch, as that the *farina* may fall on its orifice: 'tis uſually lower than the *apices*; and when we perceive it grown higher, we may conclude the fruit has begun to form itſelf, and has no further occaſion for the male duſt. Add, that as ſoon as the affair of generation is over, the male parts, together with the leaves, fall off; the reſt of the work being left to the female: and at the ſame time, the piſtil, or neck of the *uterus*, begins to contract itſelf. Nor muſt it be omitted, that the top of the piſtil is always either cover'd with a kind of velvet-facing, or emits a gummy juice, the better to catch and retain the duſt of the *apices*. In flowers that turn downward, the piſtil reaches much lower than the *ſtamina*, that the duſt may fall in ſufficient quantity from their *apices*, for the buſineſs of impregnation.

This ſyſtem of vegetable generation favours much of that admirable uniformity every where obſerv'd in the works of nature: but 'tis experience alone muſt determine for it. Accordingly, M. *Geoffroy* aſſures us, that in all the obſervations he had made, the cutting off the piſtil, before it could be impregnated by the *farina*, actually render'd the plant barren for that ſeaſon; and the fruits abortive: And the like has been obſerv'd by Mr. *Bradley*, and others.

In many kinds of plants, as the oak, pine, willow, &c. the flowers are ſterile, and grow ſeparate from the fruit: but theſe flowers, M. *Geoffroy* obſerves, have their *ſtamina* and *apices*, whoſe *farina* may eaſily impregnate the rudiments of the fruit, which are not far off.

Indeed, there is ſome difficulty in reconciling this ſyſtem with a certain ſpecies of plants which bear flowers without fruit; and another ſpecies of the ſame kind

## *Six classes of juices in plants.*

*Nutritious juice of the root and stem.*

THE *first class* comprehends the crude, *nutritious juice*, or the juices of the root and stem of plants; which are little more than the mere matter of the element as drawn by the root * from the body it adheres to, whether it be earth, water, or the like.

This

kind and denomination, which bear fruit without flowers: such are the palm, hemp, hop, poplar, &c. which are hence distinguished into *male* and *female*. For how should the *farina* of the male here come to impregnate the *ova* of the female? This difficulty M. *Geoffroy* solves, by supposing the wind to be the vehicle that conveys the male dust to the female *uterus*: which is confirm'd by an instance from *Jovianus Pontanus*, of a single female palm-tree growing in a forest, which never bore fruit; till having risen above the other trees of the forest, and being then in a condition to receive the *farina* of the male by the wind, it began to bear fruit in abundance.

For the manner wherein the male dust fecundifies the *ova*, M. *Geoffroy* advances two opinions; corresponding to the two systems of animal generation: The first, that the *farina* being always very sulphurous, and consisting of subtile penetrative parts, when it falls on the pistil, resolves; and its more active parts penetrating into the ovary, and *ova*, excite a fermentation, which putting the latent juices of the young fruit in motion, occasions the parts to unfold. In this hypothesis the grain or ovum is supposed to contain the plant in miniature; and only to want a proper juice to put it upon expanding.

In the second, the *farina* of the male plant is supposed to be the first germ or *semen* of the new plant; and that it needs nothing to enable it to unfold and grow, but a suitable *nidus*, with proper food, which it finds prepared in the ovary.

This latter opinion seems more agreeable to observation; for the little embryo's of the ovary, viewed with the best microscopes, don't discover the least appearance of a bud before the *apices* have shed their seed. In leguminous plants, if the *petala* and *stamina* be removed, and the pistil, or part which becomes the pod, be viewed with a microscope, e'er yet the flower be blown; the little, green, transparent *vesiculæ*, which are to become the grains, will appear in their natural order, but without showing any thing else beside the mere coat or skin of the grain. If the same observation be continued for several days successively in other flowers, as they advance, the *vesiculæ* will be found to swell, and by degrees to become replete with a limpid liquor, wherein, when the *farina* comes to be shed, will appear a little greenish speck or globule, floating about at liberty. This corpuscle at first shews no signs of organization; but, in process of time, as it grows in bulk, we begin to distinguish two little leaves or horns: The liquor wastes insensibly, as the corpuscle grows, till, at length, the whole grain becomes solid and opake; and then, upon opening it, we find its cavity fill'd with a young plant in miniature, and easily descry a *plumula*, or future stem; a *radicle*, or root; and the *lobes* of the bean or pea.

It may be added, that the *vesiculæ*, or grains, have little apertures which correspond to that of the pistil, by means whereof the small particles of the *farina* will find an easy passage into the embryo of the grain. To this aperture or *cicatricula*, the radicle, when form'd, corresponds; and through it, it passes, when the grain comes to germinate. *See the Memoirs de l'Acad. An.* 1711.

* If no rain, or other moisture, says Dr. *Tonge*, come at the roots of trees, they will not grow; but if only the tips or points of the roots be water'd, tho' all the rest remain dry, they will grow very well. For the points of the roots shoot out yearly a sharp-pointed tender part, something like the sharp bud at the end of

This juice is found in every part of the plant; and therefore may be held an *univerſal* juice; yet we do conſider it as the juice of the *root* and *ſtem*, becauſe it is chiefly found therein.

By what we have been able to obſerve, it is a ſubacid watery lymph, without any ſpecific taſte, or ſmell as not being yet arrived to the maturity of oilineſs. *Its qualities.*

To this claſs belong thoſe juices which diſtil in great abundance from wounds or inciſions made in the woody parts of plants †: ſuch, *e. gr.* is that tart liquor oozing from the root of the *walnut-tree*, when cut off in the month of *May*; and which is found an excellent remedy againſt the epilepſy. *In the walnut-tree.*

Such alſo is that limpid ſubacid humour flowing out very plentifully at an inciſion in the *birch-tree*, in the month of *March*, to the value of ſeveral gallons in a few days. It's a good diuretic, and commended by *Helmont* againſt the ſtone and gravel ||. *The birch.*

Such,

of a ſprig; by which the root not only enlarges itſelf in the earth, as the branches do in the air, but alſo receives its nouriſhment; and that tender part is naturally moved towards the beſt-moiſten'd and tendereſt earth. *Phil. Tranſact.* N° 44.

† From the latter end of *January* to the middle of *May*, trees will *bleed*: thoſe that are ſaid to run firſt, are the poplar, aſp, abele, maple, ſycamore; ſome, as willows, and the brill, are beſt to tap about the middle of the ſeaſon; and the walnut toward the latter end of *March*. They generally bleed a full month in the whole. The beſt time of the day for tapping, is about noon. The ſycamore will run in hard froſt, when the ſap freezes as it drops. When a large walnut would run no longer in the body or branches, it would run at the roots, and that longer on the ſouth or ſunny ſide, than on the north or ſhady ſide. Dr. *Tonge*, in *Philoſ. Tranſact.* N° 43, *&c.*

To obtain the greateſt ſtore of ſap in the ſhorteſt time from the body of a tree, bore it quite thro' the pith, and the very inner rind on the other ſide, leaving only the bark unpierced, on the north-eaſt ſide: this hole to be made ſloping upward, with a large augre, and that under a large arm near the ground. This way, the tree will in a ſhort time afford liquor enough to brew with: and with ſome of theſe ſweet ſaps one buſhel of malt will make as good ale as four buſhels with ordinary water. Sycamore, I take to yield the beſt brewing-ſap, being very ſweet and wholeſome. *Id. Ibid.*

|| The bleeding of the birch has afforded naturaliſts matter of much ſpeculation. *Willoughby*, *Ray*, *Liſter*, &c. have made a great number of experiments and obſervations thereon, which may let ſome light into the buſineſs of vegetation in general.

—In the birch, the ſap iſſues out at the leaſt twigs of branches, and the ſmalleſt fibres of roots, in proportion to their bigneſs; the gravity always promoting the diſcharge: ſo that a branch or root which bends downward, will yield much more juice than another of the ſame ſize, erect.——Branches, and young trees cut quite away, and held perpendicularly, will bleed; and if the tops be cut off, and inverted, they will bleed alſo at the little end.——In birches, no ſap iſſues out at the bark, be it ever ſo thick; but as ſoon as the bark is cut quite thro', they then firſt begin to bleed: the bark being quite off for an hand's breadth round, abates the bleeding of the tree above the pared place.——A wound made before the ſap riſes, will bleed when it does riſe.

The changes of weather have a great effect on the bleeding of plants; inſomuch that Dr. *Tonge* is of opinion, could we but obſerve it to advantage, we ſhould hence have much better indications of the alterations of weather, in reſpect of heat, cold, moiſture, *&c.* than from any weather-

*The vine.* Such, laſtly, is the juice iſſuing out of the vine, wounded in the ſpring-time, which always taſtes tartiſh, and ferments like the grapes themſelves; being held an aperitive and laxative *.

*This juice of the foſſil kind.* This juice may be eſteemed as yet foſſil being generated of, and in the earth: for the juice of the earth being received into the canals of the plant, retains its nature during two or three circulations; nor does immediately commence a vegetable juice. As is the caſe, likewiſe, in animals; the foods taken in by which, cannot be immediately converted into the animal nature; but require a ſtated time, and a certain number of circulations, concoctions, &c.

*The chyle of plants.* This claſs of juices, therefore, we look upon as the *chyle of the plant*; being chiefly found in the firſt order of veſſels, *viz.* in the roots, and the body of the plant, which anſwer to the ſtomach, and inteſtines of an animal.

The firſt humour of vegetables, therefore, is ſupplied from the earth: but in the ſurface of the earth, which is the part plants adhere to, are found bodies of all the three kinds: *viz. foſſil* bodies, and putrified parts of

ther-glaſſes. When the weather changes from warm to cold, the birches ceaſe to bleed; and upon the next warmth, begin again: But, which is very remarkable, the contrary always obtains in the walnut-tree, and frequently in the ſycamore, which, upon a fit of cold, will bleed plentifully, and as that remits, ſtop: A morning-ſun after a froſt will make the whole bleeding tribe bleed afreſh.

Laſtly, a culinary fire will have the like, or greater effect than the ſun, and immediately ſet them a bleeding in the ſevereſt weather. Branches of maple and willow, cut off at both ends, will bleed, and ceaſe at pleaſure, again and again, as you approach them to, or withdraw them from the fire; provided you balance them in the hand, and often invert them, to prevent the falling, and expence of the ſap: yet, being often heated, they will at length quite ceaſe, tho' no ſap was at any time ſenſibly loſt: and when they have given over bleeding, by being brought within the warmth of the fire, the bark will be found very full of juice.

A hard ligature, made within a quarter of an inch of the end of a wood-bine branch, Dr. *Liſter* aſſures us, did not hinder its bleeding at all, when brought within the warmth of the fire.——Maple and willow-branches, quite bared of bark, and brought to the fire, ſhew no moiſture at all. The ſame, half bared of bark, would bleed only from thoſe half of the circles cover'd with bark. A branch of ivy, of itſelf, bled a liquid yellowiſh reſin from the bark, and near the pith; but, when brought to the fire-ſide, bled a thin, dilute, colourleſs ſap, from the intermediate wood-circles. One, or both ends of the pith of a willow being ſealed up with hard wax, it will yet bleed freely by the fire.——Branches of willow cut off in a very ſevere froſty morning, and brought within the air of the fire, would ſhew no moiſture at all; no, not when held till warm, and often and long turn'd: yet the ſame branches, after lying all night on a graſs-plot, did, next morning, when the froſt was broke, freely bleed.——Laſtly, a twig of maple, whoſe top had been cut off before, and had then bled; being now taken off from the tree, and brought within the air of the fire, and held with the formerly cut end downwards, would not run at all; but with the other end down, run a-pace. *Philoſ. Tranſact.* No 48, 57, 58, 68.

* The *French* ladies uſe it to take away freckles; beſide which, M. *Reneaume* intimates another uſe it is applied to, of a quite different kind; *viz.* miracles. It ſeems, moſt of the miraculous tears, let fall by ſaints, madona's, &c. are drops of this liquor. *Mem. de l'Acad. An.* 1707.

*animals,*

*animals* and *vegetables*. Consequently this prime, radical juice of vegetables is a compound from all the three kingdoms.

II[d] Claſs of juices is that of the *leaves*. The leaves, we have already obſerved, are the real lungs of the plant; and accordingly make a further change of the juice which they receive from the roots, and ſtem, by force of the air *. The juice of the leaves, therefore, is different from the firſt juice; as being more ſulphurous, and further elaborated: not that it derives any ſulphur from the ſun; but that its watery part exhaling, it becomes more oily and leſs volatile. *Juices of the leaves.*

The juice of the leaves is of three kinds.

The firſt is the *nutritious juice* of the leaves; which is that already deſcribed; only further elaborated in the minute *veſiculæ* of the leaves, and conſequently leſs acid, and watery, and more oily, and ſaccharine.

This is that juice drawn out of the leaves, by expreſſion. *Note*, The leaves of all plants are of different taſtes, from the differences in the oil of this juice: that taken away, the taſte is the ſame in all. The oil, therefore, is their diſtinguiſhing character.

The ſecond is *wax*; which exuding † out of the leaves, adheres to their ſurface, and is ſcrap'd off by the bees, with their rough thighs, to build their combs withal. This is chiefly afforded by lavender, and roſemary: from which laſt, I my ſelf have ſometimes been able to gather wax; and by the aſſiſtance of the microſcope, any body may plainly perceive the wax ſticking on the leaves of that plant. Tho' ſome have miſtakenly imagin'd that it was from the teſticles, or *apices* of the ſtamina of the flower; and others from the *petala*, or leaves of the flower, that wax was gathered. *Wax.*

Wax therefore is a vegetable, not an animal matter: and hence it is that *Hungary* water, in which lavender is a main ingredient, is frequently found to have ſomewhat of a waxy ſmell **.

The third is *manna*; not that wherewith the *Iſraelites* were fed in the deſart, but a drug, ſold among us as an emollient, laxative medicine.

Manna is an eſſential, ſaccharine ſalt, exuding, chiefly, by night, and in the ſummer ſeaſon, from the leaves of a ſort of aſh, growing in *Cala-* *Manna.*

* The great importance of the leaves to the fruit, appears from common obſervation, *viz.* that when the caterpillars ſeize on a tree in the fruit-ſeaſon, they only feed on, and deſtroy the leaves; and yet the conſequence hereof is, that the tree ſhall frequently appear as if dead, and the fruit prove abortive. *Mem. de l'Acad. An.* 1707.

† Plants, like animals, have both a ſenſible, and inſenſible perſpiration; and when either of 'em is too copious, it frequently proves mortal. And thus it is, according to M. *Reneaume*, that the walnut-trees of *Dauphiné* uſually die, after a too profuſe load of a ſort of manna which they yield. *Mem. de l'Acad. An.* 1703.

** To procure the wax from the combs, for uſe: the honey being ſeparated from them, they put all that remains in a large cauldron, with a ſufficient quantity of water; and thus, by means of a moderate fire, melt it. This done, they ſtrain the water, &c. off, thro' a cloth in a preſs. Before it grows cold, they ſcum it well, and caſt it into moulds.

This is the *yellow wax*, which blanched and purified makes the *white-wax*.

*bria* and *Sicily*: and adhering thereto in form of a cruſt, to be gather'd next morning, e'er the ſun is up †.

It does not fall as a dew from heaven; nor is it any thing communicated from the air, as many have imagin'd; but is a ſweat exhaling from the leaves themſelves; as is evident hence, that tho' the leaves be incloſed in a phial, or cover'd up with a cloth, all night; they are ſtill found next morning with their uſual load of *manna*.

The like ſubſtance is found to exude from the leaves of the linden tree and poplar, in the heats of *May* and *June*, at which time they have a honey-taſte, and are even ſeen with a fatty juice on 'em, which at the approach of the cold evening gathers into grains.

*Juices of the flowers.*

III[d] Claſs of juices are thoſe of the *flowers*; or the genital parts of plants. In theſe are,

*Volatile oil.*

Firſt, a pure, elaborated, *volatile oil* or *ſpirit*, wherein the particular ſmell of the plant or flower reſides; and which, by reaſon of its extreme volatility, exhales ſpontaneouſly; inſomuch that if the flower be laid for ſome time in a warm place, the odorous juice or ſpirit will be all fled.

This oil, or vapour, is ſuppoſed to be the genial, or ſeminal *Aura* of the plant; or the vehicle of the embryo: conſequently, all that we ſo much admire in the ſcent of flowers, is the ſpermatic vapour. If the whole plant be bruis'd, or rub'd together; this odorous ſpirit becomes ſo mix'd, or confounded with the other juices, as to remain imperceptible. And hence the juice expreſſed from roſes becomes of a very diſagreeable ſmell, tho' the ſpirit exhaling from the flower entire, be highly grateful.

*Expreſſed juice.*

The ſecond is the juice *expreſſed* from the flower; which, in reality, is the ſame with that of the root, and leaves, only further prepared. It is thicker than the former, and has ſcarce any ſmell at all. Thus, if you bruiſe a hyacinth, or other fragrant flower, and expreſs the juice, it will be found altogether inodorous.

*Honey.*

The third is the ſweet juice call'd *honey*, which exudes from all flowers; aloes, colocynthis, and other bitter flowers not excepted.

In all male flowers, that have utricles at the bottom of the petala, is found a viſcid, ruddy, ſweet juice, in ſome plenty; and accordingly we ſee the children gather cowſlips, fox-gloves, honey-ſuckles, &c. and ſuck the honey from 'em. The bees, too, viſit theſe flowers; and putting in their proboſcides, or trunks, ſuck out the honey, and load their ſtomachs there-with,

† Beſides this ſpecies, which the *Italians* call *Manna di corpo*, they have two other ſorts of manna; one procured, as it were, by violence, and by making inciſions, which they call *Manna forzata*, or *forzatella*; and another iſſuing out at the nervous parts of the leaves, in grains as big as wheat, call'd *Manna di fronda*. There are alſo liquid manna's, brought from *Perſia*, *Egypt*, &c. but they are little known or uſed among us.

with, to be afterwards discharg'd and laid up in their combs: so that honey is a vegetable juice ||.

IV[th] Class of juices are those of the *fruit* and *seed*; the preparation whereof is nature's final work, which perform'd, the plant seems to die, for a time, as all animals are seen to languish after emission of their semen. *Juices of the fruit and seed.*

We always distinguish in plants between καρπος, and σπερμα seed and fruit; the fruit is the whole external machine, including the seed within it. Thus in an apple, the fruit being that eatable pulp, or parenchyma, in whose centre are 5 or 6 lobules with kernels, or seeds, inclosed therein. This pulp serves to foster, defend and nourish the seed; being, withal, so contriv'd by nature, that when the fruit shall fall to the ground, the pulp may support the seed, during winter, till the approach of the spring afford it proper matter, and food for growing. *Structure of the fruit.* *Its use.*

The juice of the *fruit* is like that of the root, only further elaborated. *Its juice.*

The *seed* consists of an embryo, with its coat or cover. The *embryo*, which contains the whole plant in miniature, and which is call'd the *gem* or *bud*, is rooted in the placenta, or cotyledon, which make the coat or *involucrum*, and serves the same purposes as the *secundines*, *i. e.* the chorion, and amnios, in animals. *Structure of the seed.*

The placenta, or cotyledon of a plant, is always double; and in the middle, or common centre of the two, is a point or speck, which is the embryo, or *plantule.* This plantule being acted on, and mov'd by the warmth of the sun, and the earth, begins to expand; and protrudes, or shoots out its *radicle*, or root, both upward and downward. By this it absorbs the nutritious juice, from the earth; and so grows and increases; and the requisite heat continuing, the growth continues.

Thus, *e. gr.* a pea, or bean, being committed to the ground, is, first, found to cleave into two parts; which are, as it were, two leaves, or lobes of

|| Honey was antiently taken for a dew that fell on flowers; but what proves this a mistake, is, that the bees only gather it after the sun is up, when there is no dew left. It must, therefore, either be a liquor prepared in the flower, and excreted by its proper vessels, like manna; or rather the fine dust, or *farina fecundans* of the apices: for according to the observations of M. *du Verney*, the bees, when in search of honey, fix on no other parts but the stamina, and apices, and not on such as yield any liquor.

What is very remarkable, is, that honey, in virtue of its vegetable nature, is discovered, by M. *Lemery*, to contain iron. Which discovery may, perhaps, serve as an answer to M. *Geoffroy*'s chemical question, *viz. Whether there is any part of a plant without iron*? For if so delicate an extract from the finest part of the flower, and this further elaborated in the little *viscera* of the insect, be not clear of iron, we may despair of seeing any so. See the *Hist. de l'Acad. An.* 1708.

We have two kinds of Honey, *white* and *yellow*: the white call'd also *virgin honey*, trickles out, spontaneously, from the comb, when inverted, &c. the second is expressed from the combs, in a press, after having first soften'd 'em with a little water, over the fire. There is also an intermediate sort, of a yellowish white colour, drawn by expression, without fire.

the placenta: and in the fiſſure appears a point which ſhoots out a root downwards, and a bud upwards; the firſt ſpreading it ſelf in the ſoil to catch the moiſture thereof, and the latter emerging into the air, and becoming the ſtem, or body of the new plant *.

The

* 'Tis very remarkable, how the plumule, or future ſtem ſhould always get uppermoſt; and the radicle, or root, be turn'd downwards; and this too, perpendicularly to the horizon: and not only this, but if, by any external means, the ſtem be diverted from this perpendicularity, and bent, for inſtance, toward the earth; inſtead of perſevering in that direction, it makes an angle or elbow, and redreſſes it ſelf.

The ſame is obſerv'd in trees, &c. blown down, with their roots, by the wind; or in thoſe planted in pots, upon turning the pot on one ſide.

Now, the ſeed from which a plant ariſes, being the plant it ſelf in little; 'tis eaſy to ſuppoſe, that if it be depoſited in the ground, with the plumule perpendicularly upward, and the radicle downward, the diſpoſition ſhould be maintain'd in its future growth. But 'tis known, that ſeeds ſown, either of themſelves, or by the help of man, fall at random; and among an infinite number of ſituations of the plumule, &c. the perpendicular one upwards is but one: ſo that in all the reſt, 'tis neceſſary the ſtem and root do each make a bend, to be able, the one to emerge directly upward, the other downward. Now, what force is it effects this change, which is certainly an action of violence?

M. *Dodart*, who firſt took notice of the phænomenon, accounts for it, by ſuppoſing the fibres of the ſtem of ſuch a nature, as to contract, and ſhorten, by the heat of the ſun; and lengthen by the moiſture of the earth: and on the contrary, the fibres of the root to contract by the moiſture of the earth, and lengthen by the heat of the ſun. On this principle, when the plantule is inverted, and the root a-top; the fibres of the root being unequally expoſed to the moiſture, *viz.* the lower parts more than the upper, the lower will contract more; and this contraction be promoted by the lengthening of the upper, from the action of the ſun. The conſequence whereof will be, the root's recoiling, inſinuating further into the earth, and getting beneath the body of the ſeed. In a word, the earth draws the root toward it ſelf, and the ſun promotes its deſcent; On the contrary, the ſun draws up the plume; and the earth, in ſome meaſure, ſends it towards the ſame. *Mem. de l'Acad. An.* 1700.

M. *de la Hire* accounts for the ſame perpendicularity, by only conceiving the root to draw a coarſer and heavier juice; and the ſtem a finer, and more volatile one: in the plantule, therefore, we may conceive a point of ſeparation; ſuch, as that all on one ſide, *e. gr.* the radical part, is unfolded by the groſſer, and all on the other by more ſubtle juices. If the plantule then be inverted and the root a-top; as it ſtill imbibes the groſſer and heavier juices, and the ſtem the lighter; the point of ſeparation being conceived as the fixed point of a lever, the root muſt deſcend, and at the ſame time, that the volatile juices imbibed by the ſtem, tend to make it mount. Thus is the little plant turn'd on its fix'd point of ſeparation, till it be perfectly erect. *Mem. de l'Acad.*

The plant thus erected, M. *Parent* accounts for the ſtems continuing to riſe in the vertical direction, thus: The nutricious juice being arrived at the extreme of a riſing ſtalk, and there fixing into a vegetable ſubſtance; the weight of the atmoſphere muſt determine it to fix in a vertical poſition; ſo that the ſtalk will have acquired a new part, perpendicularly over the reſt; juſt as in a candle, which held any how obliquely to the horizon, the flame will ſtill continue vertical, by the preſſure of the air. The new drops of juice that ſucceed, will follow the ſame direction, and as all together form the ſtem, that muſt of courſe be vertical, unleſs ſome particular circumſtance intervene.

Add, that whereas the branches are likewiſe obſerved, as much as poſſible, to affect perpendicularity; inſomuch, that tho' they be forced to ſhoot out of the ſtems horizontally, yet in their progreſs,

they

The two placentulæ, or cotyledones of a ſeed, are, as it were, a caſe to this little tender plantule, or point; covering it up, ſheltering it from injuries; and feeding it from their own proper ſubſtance, which the plantule receives, and draws to it ſelf, by an infinite number of little filaments, or ramifications, call'd *funes umbilicales*, or navel ſtrings, which it ſends into the body of the placenta.

Now when the ſeed is committed to the earth, the placenta ſtill adheres to the embryo for ſome time, guards it from the acceſs of noxious colds, &c. and even prepares, and purifies the cruder juice the plant is to receive from the earth, by ſtraining it, &c. through its own body. This it continues to do, till the plantula being a little enured to its new element; and its root tolerably fix'd in the ground, and fit to abſorb the juice thereof; *How it ſhoots and takes root.*

they erect themſelves; M. *Parent* ſolves this from the vertical tendency of the nutritious juice up the ſtem: for the juice being received, in this direction, into the new tender bud, finds at firſt little reſiſtance; and afterwards, as the branch grows firmer, it furniſhes a longer arm of a lever to act by. *Mem. de l'Acad.*

Laſtly, M. *Aſtruc* accounts for the perpendicular aſcent of the ſtems, and their redreſſing themſelves, when bent; on theſe two principles. 1°, That the nutritious juice ariſes from the root to the top, in longitudinal tubes, parallel to the ſides of the plant, which communicate, either by themſelves or by means of other horizontal tubes, proceeding from the circumference of the plant, and terminated in the pith. 2°, That fluids contain'd in tubes, either parallel, or oblique to the horizon; gravitate on the lower part of the tubes, and not at all on the upper.

For hence it eaſily follows, that in a plant poſited either obliquely, or parallel to the horizon, the nutritious juice will act more on the lower part of the canals, than the upper; and by that means inſinuate more into the canals communicating therewith, and be collected more copiouſly therein: thus the parts on the lower ſide will receive more accretion, and be more nouriſhed than thoſe on the upper; the conſequence whereof muſt be, that the extremity of the plant will be obliged to bend upward.

The ſame principle brings the ſeed into its due ſituation at firſt: in a bean planted upſide down, the plume and radicle are eaſily perceived, with the naked eye, to ſhoot, at firſt, directly, for about an inch; but thenceforth they begin to bend, the one downward, and the other upward.

The like is ſeen in a heap of barley, to be made into malt, in a quantity of acorns laid to ſprout in a moiſt place, &c. each grain of barley, in the firſt caſe, and each acorn in the ſecond, has a different ſituation: and yet all the buds tend directly upward, and the roots downward, and the curvity, or bend they make, is greater or leſs, as their ſituation approaches more or leſs to the direct one, wherein no curvature at all would be neceſſary. Now, two ſuch oppoſite motions cannot ariſe, without ſuppoſing ſome conſiderable difference between the two parts. The only one we know of, is, that the plume is fed by a juice imparted to it by tubes, parallel to its ſides; whereas the radicle imbibes its nouriſhment at all the pores in its ſurface. As oft, therefore, as the plume is either parallel or inclined to the horizon, the nutritious juice feeding the lower parts more than the upper, will determine its extremes to turn upward; for the reaſons already aſſigned. On the contrary, when the radicle is in the like ſituation: the nutritious juice penetrating more copiouſly thro' the upper part than the under; there will be a greater accretion of the former, than the latter; and conſequently, the radicle will be bent downwards. And this mutual curvity of the plume and radicle muſt continue till ſuch time as their ſides are nouriſh'd alike, which cannot be till they are perpendicular. *Mem. de l'Acad. Royale des Scien. An.* 1708.

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it then periſhes, and the plant may be ſaid to be *delivered*; ſo that nature obſerves the ſame method in plants, contain'd in fruits, as in animals, in the mother's womb.

*Its juice an eſſential oil.* Now, the juice of the ſeed is an *eſſential oil*, or *balm*, elaborated and exalted to its laſt perfection. This juice or oil is not found in the very point, or embryo in the centre of the placenta: all we meet with in that part, is a few fine watery particles, ſecreted from the placenta: but 'tis in the placentulæ, or cotyledones themſelves; which conſiſt of innumerable little *folliculi*, or cells, wherein this oily juice is contain'd, serving to *Great uſe of this.* defend the embryo, and preſerve it from being corrupted by water, which we all know will hardly paſs thro' oil.

Thus if you take, *e. gr.* fennel-ſeed, cut it thro' the middle, and apply it to the microſcope; you will eaſily perceive a clear ſhining oil in the cells of each lobe, inveſting the tender embryo. Without this oil, it were impoſſible a ſeed ſhould live a month, and much leſs a year, or two, entire and uncorrupted in the ground. And accordingly in divers of the mechanical arts, the ſame means, *viz.* oil, is uſed, on the ſame occaſions; *viz.* to preſerve bodies from putrifying; ſo that it appears infinitely wiſe in nature, to have depoſited ſuch an oil, or balm in thoſe ampullæ, or cells; that the embryo might remain ſecure till it came to unfold its parts, prepare for a new, and more perfect way of living, throw aſide its placenta, and truſt to its roots.

This oil is found in the ſeeds of all plants: in ſome, *e. gr.* in almonds, cocoa nuts, *&c.* in very great quantity; in others, in leſs; *e. gr.* pepper, arum, *&c.* where one would ſcarce imagine any oil at all.

It is call'd the *eſſential oil* of the plant, becauſe in it chiefly reſides the ſpecific taſte of each plant. Add, that it is in this, that the virtues of the plant are moſtly lodg'd: thus the oil expreſſed from the fennel-ſeed, from wall-nuts, *&c.* is the whole eſſence of thoſe plants, which taken away, the reſt is of little ſignificancy in medicine.

Laſtly, in the ſeed there is another ſuperfluous humour, which *exhales*; and may probably be of the ſame nature with the ſpirit or juice of the flower.

*Juices of the bark.* V<sup></sup>th Claſs of juices are thoſe of the *bark*; which is an artful congeries, or bundle of perſpirative ducts, and abſorbent veſſels; admirably explained by *Malpighi* and Dr. *Grew*.

Of theſe juices there are divers ſpecies: for the ſeveral humours rais'd and diſtributed thro' the leaves, flowers, and other parts of the plant, have all circulated thro' the bark: and accordingly are frequently found to diſtil from wounds made therein. In ſome caſes, even the whole plant is no more than bark; the pulp having been eat out, as in willows, poplars, *&c.* which will live a long time in that ſtate.

*Uſes of the bark.* The bark ſerves divers purpoſes: for it not only tranſmits the nutricious juices of the plant, but alſo contains divers fat oily humours, to defend the fleſhy parts from the injuries of the weather. As animals are furniſh'd with a *panniculus adipoſus* uſually replete with fat, which inveſts and covers all

the fleſhy parts, and ſcreens 'em from external cold ; ſo are plants incompaſs'd with a bark, replete with fat juices, by means whereof the cold is kept out ; and, in winter time, the *ſpiculæ* of ice prevented from fixing and freezing the juices in their veſſels : whence it is, that ſome ſorts of trees remain ever green, the year round, by reaſon their barks contain more oil than can be ſpent, and exhaled by the ſun, *&c.*

All the juices of barks are reducible to eight, *viz.*

1°, The crude, acid, watery juice, which we have already call'd the *chyle* of the plant.

2°, An *oily juice*, which burſting the bark in the beginning of ſummer, exudes out of divers plants, as beech, pine, fir, ſavin, juniper, and other ever-greens, and ſuch alone. This oil diſſolves by the ſmalleſt degree of warmth, and is eaſily inflamed ; and is that which defends the plant, *&c.* *Oil.*

3°, A *balm*, * or fatty liquor more glutinous than oil ; being nothing but the laſt mention'd oily juice, which was more fluid, during the ſpring-time, but which, ſince, by the greater heat of the ſun, has evaporated all its more ſubtile parts, and is converted into a denſer liquor. Thus the finer part of oil of olives being exhaled, by the ſummer's warmth, there remains a thick balſam behind : Thus alſo, oil of turpentine having loſt its more liquid parts, by heat ; becomes of the thick conſiſtence of a balm. *Balm.*

4°, A *pitchy juice*, which is the body of the oil it ſelf, inſpiſſated, and turn'd black, further than in the balm. This is moſt obſerved in the *pine* and *fir* †. *Pitch.*

5°, A

* There are three principal *balms* or *balſams* in uſe among us ; *viz.* balm of *Gilead*, of *Peru*, and *Capivi.* The firſt, which gives the denomination to all the reſt, iſſues out at inciſions made in the body of a tree, call'd *balſamum*, growing in *Egypt* and *Judea.* The juice, call'd alſo *opobalſamum*, at firſt is liquid, but afterwards hardens into the form we ſee it in. 'Tis rarely had unſophiſticated. The marks of purity and goodneſs are, to have a brisk pungent ſmell nothing tart, eaſily diſſoluble, aſtringent and pungent to the taſte. Its colour is a golden yellow, and its flavour has ſomewhat of the citron. The fruit of the tree, call'd *carpo-balſamum*, and the wood *xylo-balſamum*, have ſomewhat of the virtue of the balm it ſelf.

The balſam of *Peru* is differently denominated, according to the parts it is obtained from : *balm of inciſion* is a whitiſh, viſcid juice, diſtilling from inciſions in the tree; and afterwards dried and hardened. *Dry balm*, is of a reddiſh colour, and oozes from the tips of the branches, cut off for that purpoſe. It is like milk at firſt, and only reddens by being expoſed to the ſun. *Balm by lotion* is black, and comes from the bark, and from little branches and leaves chopt ſmall and boil'd together.

The balſam of *Copau* or *Capivi* comes from *Braſil.* It is in form of an oil ; and is either thick or tranſparent : the firſt, white, and of a reſinous taſte; the ſecond more on the yellow.

† The pitch in uſe among us, is ſaid by ſome to be a gum iſſuing from the larch, maſtic, or turpentine tree ; but in reality is no more than the juice of the pine, or fir, burnt and reduced into roſin, with a mixture of tar, to give it the colour. Sir *G. Wheeler*, gives us the way of preparing pitch, as practis'd in the *Levant* : a ditch being dug in the ground, two yards wide at top, but going leſs and leſs towards the bottom ; they fil this pit, with branches of pine ; chuſing ſuch as have the moſt gum, and

*Resin.* 5°, *Resin*, which is an oil, so far inspissated as to become friable in the cold; and may be procured from any oil, by boyling it much, and long. Thus, if turpentine be set over a gentle fire, it first dissolves, and becomes an *oil*; then a *balsam*; then *pitch*, and then a *rosin*; in which state it is friable in the cold, fusible by fire, and withal inflammable and combustible; dissoluble in spirit of wine, but not in water, which makes the character of rosin *.

Hence the *oil* is most abundant in the barks in the winter time; the *balsam* in summer; and the *resin* in autumn.

*Colophony.* 6°, *Colophony*, which is a rosin still further exhausted of its volatile part; being pellucid, friable, and approaching to the nature of glass †.

*Gum.* 7°, *Gum*, which is a humour exuding out of the bark, and by the warmth of the sun concocted, inspissated and rendered tenacious; but still dissoluble in water, and at the same time inflammable, and scarce capable of being pulverized.

Gum, therefore, appears as a sort of saponaceous fat: *i. e.* beside its oily principle, it has some other ingredient, which renders it miscible with water **. With this the gems, or buds of trees, are covered in the winter time.

*Gummous resin.* 8°, A *gummous resin*, which is a humour secreted in the bark, and dried by the heat of the sun; and thus constituting a body that is partly *gummous*, and as such, tenacious and soluble in water; and partly *resinous*, and therefore friable, and soluble in oil, or spirit of wine, but not in water.

Such are gum *armoniac*, *galbanum*, *bdellium*, *opopanax*, *sagapenum*, *tacamahaca*, &c. part whereof intimately dissolves in water; the rest remaining untouch'd at bottom.

*Blood of plants.* VI[th] Class of juices comprehends the *blood* of plants; or the juice peculiar to each species of vegetables, and not reducible to any common kind of *oils*, *waters*, *balms* or the like ||. Thus some plants, upon breaking or bruising their vessels, yield a milky humour, as the *esula*; others a yellow

and observing first to slit 'em into little shivers, which they lay over one another, till the place be full. This done, they cover the pit with fire; which burning the wood, the pitch falls down, and trickles out at a little hole made in the bottom of the pit.

* To this class belong turpentine, mastic, camphor, &c.

Some naturalists distinguish two kinds of rosins, *liquid* and *solid*. The first is the juice, just as it distils from the tree: the second only differs from this, in that it has been inspissated by the heat of the sun, or fire.

† The common colophony is only turpentine, boil'd in water, to a solid consistence. Pills made hereof are what we call turpentine pills, so much used in the venereal disease.

** Such are gum elemy, arabic, anima, tragacanth, benzoin, euphorbium, myrrh, olibanum, storax, &c.

|| The several juices hitherto recounted, are the *first*, or *nutritious juice*, call'd also the *chyle* of the plant, under such alterations and new modifications as it undergoes in being received and kept some time in parts of a peculiar structure, as leaves, flower, seed, &c. This last juice, call'd the *blood*, is the same nutritious juice further altered by being divers times pass'd thro' each of those parts, and remix'd; and at length converted into a new juice, with properties different from any of 'em all.

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ſharp one, as the *chelidonium majus*; others a yellow bitter one like gall, as aloes; and ſo of the reſt.

The botaniſts are now well agreed, that all plants are furniſhed with organs, and parts neceſſary both for chylification, and ſanguification. For they have veins, arteries, heart, lungs, adipoſe cellules, *&c.* whence it is obvious, that there muſt be ſome difference between the juices which have not undergone the action of thoſe parts, and ſuch as have already circulated a number of times. For, as in an animal, the juices prepared in the *primæ viæ*, *i. e.* in the ſtomach and inteſtines, differ much from the blood; ſo do the humours of vegetables not yet concocted, differ from ſuch as are already perfectly aſſimilated.

*Helmont*, the father, was the firſt who obſerved this difference between the juices of plants. That it is real, is evident hence, that tho' this juice be in every part of the plant, the leaves, flower, bark, wood, *&c.* and trickle out ſpontaneouſly, upon any rupture of the canals: yet, if the whole plant be rubb'd or pounded together, no ſuch juice is found therein; but only the common green juices, expreſſed from all plants.

Thus aloes, *e. gr.* bruis'd together, yields a mere green juice; tho' the juice diſtilling from the ſame, when lightly broke or wounded, be of a golden colour. Thus alſo the chelidonium, if you cut the ſtem aſunder, diſtils, as already obſerved, a yellow, golden juice; but if you rub the whole plant together, leaves and all, the juice expreſſed from it, will be quite of another kind, *viz.* green, which is common to all plants: and thus poppy, when wounded, yields a milky humour, which drying in the ſun, becomes black, and is call'd *meconium* or *opium*: but the ſame poppy, *&c.* being pounded; the juice expreſſed, will be found yellow and oily. Add, that the thing which purges ſo violently in colocynthis ſeems to reſide in this juice; for the whole plant has no ſuch effect.

The general chemical character of vegetables, which in the analyſis diſtinguiſhes 'em from foſſils, and animals, is, that when burnt to aſhes, they yield a fixed alcaline ſalt: tho' in ſome kinds this be very ſmall in quantity; particularly in ſuch as yield a ſharp ſmell, as onions and muſtard. M. *Homberg*, 'tis true, aſſures us he had drawn ſuch a ſalt from the water of a certain ſpring; but he himſelf ſuſpects that ſalt might have come into the water from the vegetables * growing therein †. *Chemical character of a vegetable.*

* Vegetable bodies are found more uniform in reſpect of their *elements*, than foſſils: in the analyſis, they all contain *ſalt*, *water*, *earth*, and *ſulphur*, but then the ſalt is of three ſeveral ſorts, *viz.* acid, urinous, and lixiviate. *Homberg*, *Mem. de l'Acad. An.* 1702. Theſe principles are all more or leſs volatile, as a greater or leſs fire is uſed: or as the plant has been fermented or not. *Id. ib. An.* 1701.

† Agreeably to the method hitherto obſerved, it will be neceſſary to ſubjoin a ſcheme, or diviſion of the ſeveral ſubjects of the vegetable kingdom.

Plants, then, are popularly divided, with reſpect to *magnitude*, into trees, *arbores*; ſhrubs, *frutices*; and herbs, or *ſuffrutices*. Again, with reſpect to their *food*, and the *element* they live in, plants are divided into *terreſtrial*, or *land-plants*; *aquatic*

 or

or water-plants; and *amphibious*, or those which live indifferently in land or water.

The botanists make more minute distributions: M. *Ray* particularly, distinguishes plants into 25 classes, or genera: *viz.* 1°, *Imperfect plants*, which are such as appear to want the flower and seed, as corals, spunges, &c. 2°, Plants producing an *imperfect flower*, and *whose seed is too small to be discerned* by the naked eye, as fern, polypody, &c. 3°, Those whose *flowers want petala*, as hops, hemp, nettles, docks. 4°, Those with a *compound flower*, and which *emit a milky juice* when cut or broke; as lettice, dandelion, succory, &c. 5°, Those with a *compound flower of a discous form*, and whose *seed is wing'd* with down; as coltsfoot, flea-bane, &c. 6°, *Herbæ capitatæ*, or those whose *flower is composed of long, fistulous flowers gathered into a round head*, and covered with a scaly coat; as the thistle, great burdock, blue-bottle, &c. 7°, *Corymbiferous plants* with a discous flower, but no down; as the daisy, yarrow, corn marygold, &c. 8°, Plants with a *perfect flower*, but only *one seed* to each flower, as valerian, agrimony, burnet, &c. 9°, *Umbelliferous plants*, with a flower of five petala, and two seeds to each flower: which being a large genus, is subdivided into 7 species, *viz.* those with a broad flat seed like a leaf, as wild garden parsnip: with a longish and larger seed, swelling in the middle, as cow-weed, and wild chervil: with a shorter seed, as angelica: with a tuberous root, as the earth nut: with a small striated seed, as caraways, saxifrage, and burnet: with a rough hairy seed, as parsly, wild carrot: with intire leaves undivided into jags, as senicle, and thorowax. 10°, *Stellate plants*, whose leaves grow round the stalks, at certain intervals, in form of stars; as mugweed, madder, &c. 11°, *Rough-leav'd plants*, which have their leaves placed alternately, or in no certain order along the stalks; as hounds-tongue, mouse-ear, &c. 12°, *Suffrutices* or *verticillate plants*, whose leaves grow by pairs, on their stalks, one leaf right against another; the flower being monopetalous, and usually in form of a helmet; as thyme, mint, penny-royal, vervain, &c. 13°, *Polyspermous*, or those *with many naked seeds*, at least more than four, succeeding their flower, as crow's-foot, marsh-mallows, cinquefoil, strawberries, &c. 14°, *Bacciferous* plants, or such as bear berries; as briony, honeysuckle, *Solomon's* seal, lilley of the valley, night shade, asparagus, &c. 15°, *Multisiliquous* or *corniculate plants*, which after each flower produce several long, slender *siliquæ*, or cases wherein their seed is contained; as orpine, navel-wort, bearsfoot, columbines, &c. 16°, *Vasculiferous plants*, or those with a *monopetalous flower*, and which after each flower have a vessel beside the calyx, containing the seed; as henbane, bind-weed, rampions, fox-glove, eye-bright, &c. 17°, Those with an uniform *tetrapetalous flower*, bearing their seeds in oblong siliquous cases, as stock-jilly-flower, mustard, radish, &c. 18°, *Vasculiferous plants*, with a *seeming tetrapetalous flower*, but of an anomalous, or uncertain kind, and in reality only monopetalous, falling off all together in one, as speedwell, fluellin, plaintain, yellow and wild poppy, &c. 19°, *Leguminous plants*, or such as bear pulse, with a papilionaceous flower, consisting of four parts, join'd at the edges; as peas, beans, vetches, tares, lentiles, liquorice, trefoil, &c. 20°, *Vasculiferous plants*, with a *pentapetalous* or *five-headed flower*; as maiden pinks, campions, chickweed, St. *John's* wort, flax, primrose, wood-sorrel, &c. 21°, Plants with a *true bulbous root*, as garlic, daffodil, hyacinth, saffron, &c. 22°, Those whose *roots approach nearly to the bulbous form*, as flower de luce, cuckoo-pint, bastard hellebore, &c. 23°, *Culmiferous plants*, with a grassy leaf, and an imperfect flower, having a smooth, hollow, jointed stalk, with a long sharp-pointed leaf at each joint, and the seed contained in a chaffy husk; as wheat, barley, rye, oats, and most kind of grasses. 24°, Plants with a *grassy leaf*, but *not culmiferous*, with an imperfect, or stamineous flower; as rushes, cats-tail, &c. 25°, Plants, whose place of growth is uncertain; chiefly water plants, as the water-lilly, milk-wort, mouse-tail, &c.

# *Of* A N I M A L S;

## OR, THE

## ANIMAL KINGDOM.

AN *animal* (respect being only had to the body, not the soul,) *is an organical body, consisting of vessels and juices; and taking in the matter of its nutriment*, by a part call'd *a mouth*; *whence it is conveyed into* another, call'd *the intestines, into which it has roots implanted, whereby it draws in its nourishment, after the manner of plants.* *Animal defined.*

From this definition it appears, that an animal is distinguish'd, 1°, From a *fossil*, in that it is *an organical body*, consisting of vessels and juices; and 2°, From a *vegetable*, on this only account, that an animal has its roots within *it self*, and a plant without it self. Nor let this appear a paradox: for the intestines of an animal are, in reality, no more than its earth, or the body it adheres to; into which it sends forth its *roots*, that is, the lacteal vessels, which thence draw the matter of its life, and increase. *Distinguish'd from fossils and vegetables.*

If it be inquired why we do not define an animal from its *heart?* 'tis answered, that we don't know whether all animals have such a part; for as there are several have 16 hearts, particularly the silk-worm; and some have even 60; so 'tis possible there may be others have none at all. Nor can any general character of an animal be taken from the *brain*, the *lungs*, or the like; since we know of many quite destitute thereof.

The proper genuine characteristic *, then, of an animal, is to be free, and at large with respect to the subject it derives its nourishment from. For every thing is taken in by the mouth; but the mouth does not adhere to any thing. Whereas all plants are connected, in some manner or other, to the body which furnishes 'em food †.

Hence

* The ingenious Dr. *Tyson* fixes the criterion of an animal to be, a *ductus alimentalis*, *i. e.* a gula, stomach, and intestines, all which make but one continued canal.

† As circumspect as our author has been in framing his definition, there may, perhaps, be animals it does not agree to; and such we take *mussels* to be. That anomalous creature breathes, and receives its nourishment, not at the mouth, but by the *anus*. The part which we account its *head*, tho' without either eyes, ears, or tongue, or any other apparatus, save a hole, which we may call its *mouth*; is an immoveable part; being fastened to one of the shells, so, that it cannot go to seek for food, but the food must come to seek it. This food is water,

Hence it follows, that a fœtus, while it remains in the mother's womb, is a real plant; as being connected by the *funiculus umbilicalis* to the *placenta*, and by the *placenta* to the *uterus*, from which it receives its nutriment. If it did not derive its food by the said funiculus, but by its mouth, it were an animal*; and if it drew it by both, a *neophyta*, or plant-animal.

Some have defined animals from their loco-motion, as being capable of shifting from place to place; and plants from their sticking fast to the same subject: but on this principle oisters, mussels, cockles, &c. are excluded from the class of animals, inasmuch as they adhere, or grow to rocks, &c. † yet

water, which, as the shells open, enters in at the *anus* of the mussel, which opens at the same time; and passing thence into certain canals between the inner surface of the shell and the outer surface of the animal, is conveyed thence into its mouth, by a certain motion which the animal can produce at pleasure. From the bottom of the mouth proceeds a sort of intestine, which passing thro' the brain, and making several circumvolutions in the liver, traverses the heart, and terminates in the *anus*. Nor does the canal, taken for an intestine, seem proper to carry the food for the nourishment of the parts; since it does not distribute any branches thereto. Add, that it has no veins, or arteries, nor any circulation: and, what is yet further surprizing, it is an hermaphrodite; but an hermaphrodite differing from all others of that kind known, in that it propagates independently of any other animal, and is it self both the father and the mother of its own offspring. See its anatomy at length in the *Mem. de l'Acad. R. de Scienc.*

* "How the fœtus is nourished in the "womb, Dr. *Drake* observes, is a question "as much agitated among anatomists as "any whatever: some contend that it is "nourished by the mouth; others will "have it receive its increase, and grow "like a vegetable, from the mother as "from the root, of which the umbilical "vessels are the stem, and the child the "head or fruit." *Anthropol. l.* 1. *c.* 22. Were it not for that small share of muscular motion, which the fœtus exercises in the womb, it might without absurdity be accounted as a graft upon a branch of the mother. *Id. ib. l.* 2. *c.* 7.

† Some of our latest naturalists have discovered a progressive motion in several shell-fish, which were reputed to be fixed. M. *Poupart*, in particular, shews that mussels walk on the ground, and some species of 'em, even tumble along the surface of the water. Their way of walking is thus: lying on the flat of their shells, they thrust out a part, in form of a tongue, which from its use may be called the *arm*: with this they make little motions to the right and left, and by that means dig a passage in the sand, or mud of the place. In this digging, they stoop gradually on one side; and so get the shell mounted on edge. This done, they stretch the arm out, as far as they can, for a minute or two; and then rest on its extremity, to draw the shell after 'em, as water-snails do. Which motion they repeat as long as they mean to walk; thus forming themselves a sort of groove, in the sand, which sustains the shell on either side; and leaving behind 'em a sort of irregular track, three or four yards long. In rivers, &c. that abound in mussels, one sees abundance of these tracks, and a mussel always at the end of 'em. M. *Poupart* adds, that not having discovered any muscles whereby this motion should be effected, he supposes that they only stretch out of the shell by imbibing a great quantity of water. *Mem. de l'Acad. An.* 1706.

In sea-mussels, M. *Reaumur* has observed, that what we may call the *arm* or *leg*, which in its natural state is not above two lines long, may reach out of the shell above two inches; and the animal having laid hold of some fixed point, with this arm thus stretch'd out, bends, and shortens it, and thus drags the body after. *Mem. de l'Acad.* 1710.

Monf.

yet 'tis certain, that those creatures are real animals, as they have mouths and stomachs to take in their food, and lacteals and mesenteric veins to receive it.

We shall add, that beside their proper body, they likewise feed and maintain their house, or *shell*, from the same *roots*; the shell being found to adhere to the body by an infinity of little vessels, thro' which the circulation is effected.

As to the structure of those shells: they consist of an infinite number of lamellæ, or thin membranes; intermix'd, and fortified with a stoney cretaceous matter, from which arise the vessels abovemention'd. One lamella they produce every year; and put off, or lay aside another, as snakes &c. do their skins *. *Structure of the shells of animals.*

Animals

Monsf. *Mery*, in his anatomy of the pond-mussel, shews that the whole belly of the animal, when it walks, thrusts out of the shell, in form of the keel of a ship; and that it creeps on its belly as the serpent does. He even describes the muscles, by whose alternate action the whole mechanism is perform'd. *Mem. de l'Acad. An.* 1710.

The *avignon*, a shell-fish, frequent on the coasts of *Poitou*, of the species of those call'd by the naturalists *chamæ*, or *hiatula*, adheres, by its shell, to the bottom; and has a motion the length of two horns, which it thrusts out of its shell, and therewith receives, and expels the water it needs for respiration. The *goats-eye* by naturalists call'd *lepas* and *patella*, is a shell-fish, of a single piece, always growing to a stone, upon which its lower surface is applied: the only motion it appears to have, is to raise the shell about a line from the stone; and thus leave so much of its body bare to the water: but M. *Reaumur* shews, that it has likewise somewhat of a progressive motion along its stone.

The *sea-nettle* put *Pliny* in doubt to which class of bodies to refer it, plants or animals; but he concludes, after *Aristotle*, to make it of an intermediate kind. Its most usual figure is that of a truncated cone, the larger base whereof is always fastened on a stone. The planes of its two bases are circular muscles; and there are recti, or streight muscles, proceeding from one to t'other. All the progressive motion of this animal consists in this, that one half of the muscles of both kinds, which are on the side to which it would move, swells and extends; while the other half, thus weigh'd down, is either drawn after it, or pushes it forward the same way. But the motion here is scarce so swift, or sensible, as that of the hand of a dial-plate. There is another species of sea-nettle, which does not grow to any thing; popularly call'd, and accounted as a *sea-jelly*; which it perfectly resembles, both in colour and consistence: so that if it be held a little in the hand, the single warmth thereof will entirely dissolve it into water. The warmth of a summer's day or two exhales, and reduces it to mere nothing; leaving only behind it a thin pellicle, like a fine parchment. What places it in the class of animals, is, that it has a systole and diastole, the only symptom it gives of life. *Id. ib.*

* The formation of shells is well accounted for by M. *Reaumur*: before him, naturalists had been contented to suppose the animal, and its shell, to arise from the same egg; and to feed and grow together: but that author gives us other notions. He has found by evident experiment, that the shell, *e. gr.* of garden snails, is form'd of the matter that perspires from the body, harden'd after its discharge by the air. 'Tis certain, that all animals do also perspire, and are surrounded with a sort of cloud, or atmosphere, exhaled from 'em, and which 'tis probable assumes somewhat of this external figure: and what snails, &c. have peculiar to 'em, is, that the atmosphere of their perspiration condenses and hardens around 'em, and forms 'em a visible cover, whereof their body is, as it were, the core; whereas what other animals perspire, evaporates, and loses it self in air. This difference arises from the different substance tran-

Animals consist of firm, or *solid* parts; and *fluid* parts: tho' some reckon a third kind of parts, of an intermediate nature; as *civet*.

*Animal solids mere earth.*

The *solid parts* of an animal are nothing but *mere earth*, whose particles are bound, or connected together by some oil or other humour: and into such *earth* are the bones, membranes, *&c.* of all animals resolvable.

Thus, having drawn all the moisture we possibly could out of an ox's bone, by boiling it, and from time to time pouring on fresh water, and pouring

transpired; that from snails, *&c.* being viscid, and cretaceous, as M. *Reaumur* finds by experiment.

On this principle, tho' the shell do the office of an universal bone, it does not grow like a bone, nor like the other parts of an animal, by intro-susception, that is, by a juice circulating within it self; but by *juxta-position, i. e.* an external addition of parts, over one another; as stones are usually suppos'd to grow. And it is worth observing, that there is an animal substance which grows after the manner of fossils.

To be a little more explicit: it must be remembered, that the head of a snail is always next the aperture of the shell, and its tail towards the point or apex thereof; and that its body, from some cause or other, naturally forms it self into a spiral, the different turns or circumvolutions whereof, are in different planes. This supposed, take a snail just hatch'd, and yet in its first littleness: since the matter it perspires petrifies around it, it must first have a little cover, proportional to the bigness of its body; and as its body is yet too little to make a turn of one spiral, at least a whole turn; this cover will only be the center, or, as it were, the beginning of a little turn of a spiral. But the animal continues growing: if it ceas'd withal to transpire, 'tis evident that so much as it should be increas'd by, would remain naked: but as it continues to transpire, it makes it self a new covering, in proportion as it grows, which new cover is added at the extremity of the first; and if the snail have grown to make a second spiral turn, the shell also makes a second: at the same time, the animal has likewise grown in thickness, so that this second turn, is bigger than the first. The rest go on in the same manner: and in an ordinary garden-snail there may be some four or five such circumvolutions.

Hence we see why the first turns of a young snail, which, for instance, has only form'd two, are as big as those same turns of an older snail; for what is once form'd of a shell, does not grow any further, except in thickness: and accordingly, tho' the first circumvolutions of a young snail's shell be as long and broad as those of an old one, they are not so thick. *Mem. de l'Acad. R. des Scienc. An.* 1709.

M. *Mery* objects, that tho' this formation may hold in the shells of snails, yet it does not in the shells of mussels: for 1°, These shells are visibly composed of several laminæ, or leaves, which standing out beyond each other, form distinct bands, or zones, on the outer surface thereof; and the little shells are found to have as many of these bands, as the greatest: whence it follows, that mussel-shells grow like the other parts of animals, which, how little soever they be, do always consist of the same number of parts. 2°, Add, that the bands in the shell of a little mussel, are less than in a large one; and of consequence must grow as the animal does, and in the same manner. 3°, A mussel has eight little muscles fastened to the inner surface of its two shells: now if the shells did not grow in the same manner as the fish, it would follow, that those which at first were fastened in certain parts of the young mussel, must be continually changing their place of fastening, to the utmost growth of the animal; which scarce seems possible, and has no parallel in any animal known. *Mem. de l' Acad. An.* 1710.

But M. *Reaumur* vindicates his system from all these objections: to the two first he answers, that there are sometimes even more bands in a lesser mussel-shell than a greater; but that this does not argue either intro-susception or juxta-position, being entirely owing to this, that the distinction

pouring off the old, till it come off as clean and pure as it went on ; and proceeding, ſtill further, to drain it, by burning it in a very intenſe fire, till it was perfectly white : its lamellæ appeared all very diſtinct, and we could eaſily perceive it to be *mere earth*, which the leaſt force would crumble into duſt, for want of the natural cement : yet, the ſame bone, tender, and friable as it is, if it be but immerſed in oil or water, becomes firm and ſtrong again; and more ſo in oil, than water. This, the metalliſts, and refiners are very ſenſible of : for as in the purifying and eſſaying of metals, it is neceſſary they have cupels that are incapable of vitrifying ; and as all earth, that has oil or ſalt in it, is convertible by force of fire into glaſs : they procure ſome of this pure, animal earth ; by burning fleſh, bones, or the like, to a white calx : and a veſſel made of this, no fire can vitrify ; eſpecially if the calx or earth be frequently waſh'd in water, to take away all the ſalt, and ſand, which the fire had left. *Cupels made thereof.*

Now, this *earth* * is the ſame in all bodies : in effect, the ſolid part of animals is the ſame with that of vegetables ; ſetting aſide this difference, that the ſolids of animals may, perhaps, be ſomewhat more ſubtile, and volatile, than thoſe of vegetables.

The *fluid parts* of animals, as of vegetables, are ſtill the more crude as they are leſs diſtant from the roots, *i. e.* from the lacteal and abſorbent veſſels. Conſequently *chyle* is no other than a vegetable juice ; and accordingly, if poured on blood, it ſwims thereon. This chyle, as it is further prepared in the inteſtines, and received into the lacteals, approaches more to the nature of an animal juice, and loſes of its vegetable nature ; till, at length mixing with the blood, and undergoing divers circulations therein, it becomes a perfect animal juice, and is called *blood*. *Animal fluids. Chyle. Blood.*

This blood is the moſt univerſal humour in the whole body ; as being in reality the ſource from which are derived, and into which are again diſcharged, all the other particular juices in the body. The *cruor*, or red part of the blood, again, differs from the *ſerum*, or watry part ; the ſerum from the *lympha* ; the lympha from the *nervous juice* ; this from the humour of the *glands* ; that from the *ſaliva* : the ſaliva from the *mucus* ; the mucus from the *cerumen*, or ear-wax, † *&c.*

ction of the bands is liable to be diſturbed, and two to be made appear as only one, by the edges of the laminæ, that lap over, being broke or wore down, by the attrition of the ſand, ſea-water, *&c.* The third difficulty he obviates by a parallel caſe : crabs, lobſters, *&c.* are cover'd with an external cruſt, or ſhell ; and have muſcles or ligaments, wherewith they are faſtened on the inſide thereof : and yet they caſt their ſhells every year ; and take new ones : notwithſtanding which, they are always found faſt tyed in their ſhells, and never looſe therein. Conſequently their muſcles or ligaments muſt be transferred from the old cruſt to the new : and the mechaniſm whereby that is effected, may be applied to muſſels. *Mem. de l'Acad. An.* 1716.

* See the article *earth*, conſider'd as an inſtrument, or element.

† It would carry us too far, to enter into the nature, characters, origin, office, *&c.* of the ſeveral parts, juices, *&c.* of an animal body : the reader that wants information in theſe, muſt be referr'd to the writers of *Anatomy*.

Again,

Again, there are particular humours ſeparated from the ſeveral viſcera; as the *bile*, from the liver; *milk* from the breaſts; the *pancreatic* juice from the pancreas, *&c.*

The juices of animals are diſtinguiſhed from thoſe of vegetables by two circumſtances.

*Diſtinguiſhed from the juices of vegetables.*

1°, In that, when burnt, their aſhes are found perfectly inſipid; all animal ſalts being volatile, and flying off with heat: the contrary of which is obſerved in vegetables; which conſtantly leave ſome fixed ſalts in all their aſhes.

2°, That there is no ſincere acid in any animal juice; nor can any acid ſalt be extracted out of the ſame: the contrary whereof we find in all vegetables.

*Principles of animals.*

The principles, or component parts of animals, are *,

*Spirit of animals.*

1°, *Spirit:* by ſpirit we mean any ſulphurous, or oily matter, ſo attenuated and ſubtilized, as to become volatile, by the ſmalleſt fire, and miſcible with water; which characters, where they concur in the ſame ſubject, denominate it a *ſpirit.*

Now, that there is ſuch a ſpirit in man, and a peculiar one, too, in every man; is evident from dogs; particularly thoſe of the blood-hound kind; which will follow their maſter's track, and diſtinguiſh it preciſely, even tho' a thouſand other perſons have paſs'd the ſame way. Hence, as 'tis by mere force of ſmelling, that the animal is able to do this; it follows, that there muſt be ſome ſpecific matter exhaled from the body of the maſter, which the animal can diſtinguiſh from the *effluvia* of all other perſons. Now, this ſmell cannot ariſe from the watery part: for pure water is in-odorous, and inſipid: But all ſmells ariſe from oil or ſulphur; conſequently, 'tis ſome ſubtle, oily, or ſulphurous parts, which the dog here diſtinguiſhes. And theſe are what we call *ſpirit.*

The like ſpirit is in other animals: Thus, our hunters going out in a morning, will put a hound in the track which a deer, hare, or the like animal has lately been in; and the dog, if he be good, will follow the ſteps of that particular deer thro' all the croſs paths of a thouſand others, and at laſt ſingle that individual deer among a whole herd.

This ſpirit alone it is whereby animals are diſtinguiſhed: The other parts afford no criterions. Thus, a dog can ſcarce diſtinguiſh any thing of animal, when kill'd.

*Water.*

2°, *Water*, which is always drawn in great abundance from all parts of animals; nay, from the very bones; as well as from the fleſh, ſaliva, pancreatic juice, lymph, blood, ſerum, and urine: all which, when committed to the fire, are found to conſiſt moſtly of water. In the water it is

** "Animals afford the ſame elements, "by a chemical analyſis, as vegetables; "*viz.* ſalt, ſulphur, earth, and water; "with this difference, that the ſalt of vegetables is of three ſorts, and that of "animals only two, *viz.* urinous and lixiviate, without any manifeſt acid." *Homberg. Mem. de l'Acad. R. An.* 1702.

is that the ſpirit reſides; and theſe two together make the matter of inſenſible perſpiration.

3°, *Salt*; but of what kind, we are to learn from the proceſſes hereafter laid down. *Salt.*

Some learned men will have it an *alcaline* ſalt; but this we can ſafely aver, that we never met with any ſuch ſalt in any animal body. Nor is it *acid*, (acid chyle being here out of the queſtion, inaſmuch as chyle, we have already obſerv'd, is not any proper animal juice.) Nor is it perfectly *volatile*; as appears hence, that if you evaporate human blood by a gentle fire, the ſalt will not riſe, but only the ſpirit, and water. Nor yet is it *fix'd*; for if you calcine twenty pounds of human blood, you will not get ſo much as a grain of fixed ſalt from it. Nor is it a *ſal ammoniac*; for ſal ammoniac being ſublimed, or raiſed by fire, remains immutable; and this, tho' you diſtil it again, and again: but diſtillation renders the ſalt of animals alcaline, and quite deſtroys all its ſal-ammoniacal nature.

Upon the whole, we may call it a compound ſalt, conſiſting of a moderately volatile ſalt; neither quite volatile, nor quite fix'd; not quite acid, nor quite alcaline, nor quite ammoniacal; but ſoft, and benign, and approaching neareſt to the nature of a ſal-ammoniac. *Of what kind.*

Such is the real idea of the animal ſalt; and yet the ſalts of all animals, if reduced to their laſt ſimplicity, are all found perfectly volatile. Human urine, *e. gr.* is a proper lixivium, *i. e.* a ſalino-ſaponaceous water, which waſhes all the ſalt out of the blood; and this, if purged of all its other principles, both earthy, watery, and oily, volatilizes with the ſmalleſt degree of heat, and flies all away *in fumo.* Add, that it is ſo acrimonious as to corrode all bodies it touches; and ſo light and ſubtle, as ſcarce to be retainable in cold, not at all in heat.

Such is the ſimple elementary ſalt of animals: but it cannot be ſhewn, that ſuch ſalt exiſts in any urine; but is the mere reſult of diſtillation.

4°, *Oil*, which being reduced to its laſt ſimplicity, reſolves into a ſubtile, or volatile oil, and earth. This oil is various, according to the circumſtances of the ſalts, or other principles inherent in it: But the volatile oil being perfectly clear'd of all ſalt, and earth, is a ſimple, inactive body; and in all reſpects the ſame in all animals. *Oil.*

5°, *Earth*, of which we have already ſpoke; and which we have ſhewn to be alike in all animals; perfectly immutable, and only differing from vegetable earth, in its being a little more volatile. *Earth.*

Animals, conſider'd as the ſubjects of chemical operations, are either taken *whole*; as in inſects: or in *parts*; which are either *ſolid*, and *external*, as *ſhells*, *horns* and *hoofs*; or *internal*, and *ſofter*; as *fat*, *bile*, *&c.* or *excrementitious*, as *urine*, *&c.* or, laſtly, morbid parts, and excreſcencies; as *pearls*, *bezoar*, *pietra del porco*; and the like.

# OF THE OPERATIONS OF CHEMISTRY.

WE begun the theory of chemiſtry with a definition of the art itſelf; noting, by the way, that the whole theory would be comprized under the explication of that ſingle definition. Accordingly, we began to examine the ſeveral parts thereof; and ſhew'd, 1°, How it was an *art*, from the very idea of art allow'd by all approved authors. 2°, Its object, *viz. ſenſible bodies contain'd in veſſels*, we divided into general claſſes, and laid down the ſeveral characters and properties of each. This general diviſion of nature comprehends three kingdoms; each of which we ſubdivided into inferior claſſes, or provinces: and have thus given a philoſophical account of all bodies that are known, and have any relation to chemiſtry——It remains, that we proceed in the further explication of the ſame definition. And, as we have ſaid, that chemiſtry *changes the bodies*, already mention'd, *by means of certain operations*; we are to treat of theſe operations.

*Chemical operations change bodies by means of motion.*

Now every operation which chemiſtry performs on bodies, *changes* thoſe bodies; for unleſs they were changed, chemiſtry would have done nothing: and every *change* which chemiſtry produces in bodies, is the effect of *motion*: For who can conceive a thing changed, without a motion made either in the parts, or the whole? If a body be abſolutely at reſt, it will ſtill excite the ſame idea, *i. e.* it will not be at all changed: But when a motion is communicated to it, it is ſtrait changed, and changes the idea the mind had before conceived of the ſame *.

'Tis

* Motion, thus, being the means whereby chemiſtry operates; the doctrine of motion, *i. e. mechanics*, becomes the key, whereby its operations are to be accounted for. So far, then, as we know of the nature, and laws of motion; ſo much we may conceive of the means whereby a chemical effect is produced. But our know-

'T is a miſtake, therefore, in certain chemiſts, who deny the changes produced by chemiſtry to be *mechanical*; among whom, is *Helmont* the elder, who contends for I know not what irradiation, excited by the art. But we aſk, whether mercury, without it be ſome way moved, will not ſtill remain mercury? And whether, if the philoſopher's ſtone convert it into gold, the change is not effected by motion? We own, there is no acknowledge here, God knows, is very ſcanty, and confined to narrow bounds: many of the laws of motion, percuſſion, &c. in ſenſible bodies, under various circumſtances, as falling, projected, &c. are well aſcertained by the later philoſophers; but theſe will not reach to thoſe more remote, inteſtine motions of the component particles of thoſe ſame bodies, whereon the changes of texture, colour, properties, &c. induced by chemiſtry, depend. Beſide the common laws of ſenſible maſſes, the minute parts they are compoſed of, ſeem ſubject to ſome others, which have been but lately taken notice of, and are yet little more than gueſs'd about. Sir *I. Newton*, to whoſe happy penetration we owe the hint, contents himſelf to eſtabliſh, that there are ſuch motions in the *minima naturæ*, and that they flow from certain powers, or forces not reducible to any of thoſe in the great world. In virtue of theſe powers, he ſhews, that the ſmall particles of bodies act on one another even at a diſtance; and that many of the phænomena of nature are the reſult hereof. Even ſenſible bodies, we know, act on one another divers ways; as by gravity, magnetiſm, and electricity, which are directed by different laws: And as we thus perceive the tenor and courſe of nature, it will appear highly probable, there may be other powers. Theſe juſt mention'd, reach to ſenſible diſtances, and ſo have been obſerv'd by vulgar eyes: But there may be others, which reach to ſuch ſmall diſtances, as have hitherto eſcaped obſervation; and 'tis probable electricity may reach to ſuch diſtances, even without being excited by friction.

The great author juſt mention'd, proceeds to confirm the reality of theſe ſuſpicions from a great number of phænomena, and experiments which plainly argue ſuch powers and actions between the particles, *e.gr.* of ſalts and water, oil of vitriol and water, *Aqua fortis* and iron, ſpirit of vitriol and ſalt-petre. He alſo ſhews, that theſe powers, &c. are unequally ſtrong between different bodies, between the particles of ſalt of tartar, for inſtance, and thoſe of *Aqua fortis*, than thoſe of ſilver; between *Aqua fortis* and *Lapis calaminaris*, than iron; iron more than copper, copper more than ſilver or mercury. So, ſpirit of vitriol acts on water, but more on iron or copper, &c.

Theſe actions, in virtue whereof the particles of the bodies above-mention'd tend toward each other, the author calls by a general, indefinite name, *attraction*; which is equally applicable to all actions whereby bodies tend towards one another, whether in virtue of their weight, magnetiſm, electricity, impulſe, or any other more latent power: for 'tis not the cauſe determining the bodies to approach, that he expreſſes by this name; but the effect, *i.e.* the approach: the cauſe he has no regard to, till ſuch time as the effect is well aſcertain'd. In his philoſophy, the reſearch into cauſes is the laſt thing; and never comes in turn, till the laws and phænomena of the effect be ſettled: it being to theſe phænomena that the cauſe is to be accommodated. But the cauſe even of any, the groſſeſt, and moſt ſenſible of theſe actions, is not adequately known: How impulſe itſelf works its effect, would confound the deepeſt philoſopher; yet is impulſe received into mathematics: and the laws and phænomena of its effect, make the greateſt part of the *common mechanics.* The other ſpecies of attractions, therefore, when their phænomena are ſufficiently aſcertain'd, have the ſame title to be promoted from phyſical to mathematical conſideration; and this without any previous inquiry into their cauſes, which our conceptions may not be proportionate to: Let their *cauſes* be *occult*, as all cauſes ever will be; ſo as their effects, which alone im-

accounting by what motion the ſtone ſhould in a moment's time change al the particles of the mercury into gold: but it will be evident to any perſon who attentively conſiders the thing, that there muſt be ſome infinitely little corpuſcles, which penetrating the minute globules of the mercury, fix and bind them together. And the ſame may be ſaid of the action of an univerſal diſſolvent, which is to reduce gold into its principles, *viz.* mercury and ſulphur: For muſt not there be a real ſeparation of the particles?

To this it is objected by ſome modern philoſophers, that there is motion frequently produced from principles which are at reſt: Thus, ſay they, the magnet is not moved, and yet it attracts iron; ſo the ſoul, unmoved itſelf, moves the body at pleaſure.

To which we anſwer, that we never maintained the firſt cauſe of motion, to be a motion; but only, that if one body change, or act on another, 'tis wholly by means of motion that it is enabled to effect it: Thus the magnet, to change the iron, or to act upon it, muſt move it. And thus the mind, to act on the body, muſt give it motion *.

All

immediately concern us, be but apparent. Our noble countryman, then, far from adulterating philoſophy with any thing foreign or metaphyſical, as ſome have reproach'd him; has the glory of opening a new ſource of ſublimer mechanics, which, duly cultivated, might be of infinitely more extent than all the mechanics yet known. 'Tis hence alone we muſt expect to learn the manner of the *changes*, *productions*, *generations*, *corruptions*, &c. of natural things; which are the great object of that part of philoſophy call'd *chemiſtry*.

Some of our own countrymen have proſecuted the diſcovery with laudable zeal: Dr. *Keill*, particularly, has endeavour'd to deduce ſome of the laws of this new *action*; and applied them to ſolve ſome of the more general phænomena of bodies, as *coheſion*, *fluidity*, *elaſticity*, *ſoftneſs*, *fermentation*, *coagulation*, &c. And Dr. *Friend*, ſeconding him, has made a further application of the ſame principles, to account, at once, for almoſt all the phænomena that chemiſtry preſents. So that the new mechanics ſhould ſeem already rais'd to a compleat ſcience: And nothing can now turn up, but we have an immediate ſolution of, from the attractive force.

But this ſeems a little too precipitate; a principle, ſo fertile, ſhould have been further exhauſted; its particular laws, limits, &c. more induſtriouſly detected, and laid down, e'er we had gone to application. Attraction, in the groſs, is ſo complex a thing, that it may ſolve a thouſand different things alike: The notion is but one degree more ſimple, and preciſe, than action itſelf: and till more of its properties are aſcertain'd, it were better to apply it leſs, and ſtudy it more.

* The ſame holds in the natural world; all the phænomena, the changes in the univerſe, are the effects of motion. Accordingly, to have a ſucceſſion of ſuch changes, the author of nature has added to bodies, certain active principles to be the ſources of motion.—Nature, ſays Sir *I. Newton*, performs all the great motions of the heavenly bodies by the attraction of gravity, which intercedes thoſe bodies; and almoſt all the ſmall ones of their particles, by ſome other attractive, and repelling powers which intercede the particles. Body itſelf, is merely paſſive, and needed ſome other principle to move it; and now that it is in motion, it needs ſome other principle for conſerving that motion. By the tenacity of fluids, the attrition of their parts, and the weakneſs of elaſticity in ſolids, the motion which we find in the world, is always dwindling, and on the decay; ſo that there ariſes a neceſſity of recruiting it by active principles: ſuch are the cauſe of gravity, by which planets and comets keep their motions in their orbs, and bodies

All the operations, therefore, which chemiſtry performs on bodies, are mere changes in reſpect of motion. Now a body may be changed, in motion, two ways: either when its whole bulk is removed from place to place; which does not come under the conſideration of chemiſtry, but of mechanics: or, when its parts are changed among themſelves, *i. e.* when there is a tranſpoſition of its conſtituent parts.

*Divers kinds of motion belonging to chemiſtry.*

Of this laſt kind of change, there are four caſes. 1°, When motions, which before did not exiſt, are excited. 2°, When motions before exiſting, are ſtopped. 3°, When motions are increaſed or diminiſhed. 4°, When they are determined, or new modified, without any change of the quantity of motion. To ſome or other of which heads, may all the poſſible changes in the parts of bodies be referred.

Hence we conclude, that the mutation induced by chemiſtry, does not go ſo far as the laſt elements or atoms †: for all action terminates in the ſeparation of the elements, without making any alteration therein. If any perſon thinks to go further, he is wretchedly miſtaken: For my own part, I know of no operation, but has its limit; beyond which, it does not proceed. Thus, pure gold may be converted by ſpirit of ſea-ſalt into a ſort of water; but if any body ſhould think that the gold is now changed, he will be undeceived, by ſeeing the whole gold reduced into its former pure maſs, without the loſs of one millionth part of a grain. Pure gold may likewiſe be converted into a butter: but it is eaſily return'd into its former ſtate. I can diſſolve one ſingle grain of gold in a thouſand grains of mercury, and recover it without any diminution of weight.

dies acquire motion in falling; and ſuch the cauſe of fermentation, by which the heart and blood of animals are kept in perpetual motion, the inward parts of the earth are conſtantly warm'd, bodies burn and ſhine, mountains take fire, caverns blown up, &c. For we ſee but little motion in the world, beſide what is owing to theſe active principles: And were it not for theſe, the bodies of the earth, planets, comets, ſun, and all things in them, would grow cold, and freeze, and become unactive maſſes. *Optic.* p. 373, & 375.

† Thus the great *Engliſh* philoſopher: All bodies ſeem to be compoſed of hard particles; for all bodies, ſo far as experience reaches, are either hard of themſelves, or may be render'd hard; *viz.* ſome by freezing, as waters, oils, &c. others, as mercury, by fumes of lead; and ſpirits of wine, and urine, by dephlegmating and mixing them: even the rays of light themſelves are hard bodies, as appears from their retaining different properties in their different ſides. Many compound bodies are very hard, notwithſtanding that they are very porous, and conſiſt of parts that are only laid together: How much harder, then, muſt the ſimple particles, or atoms themſelves be, which are entirely devoid of all pores? And how ſuch particles, by only laying them together, and touching in a few points, ſhould cohere, and ſo firmly, without the intervention of ſomething that *attracts*, or perhaps even preſſes them together; can ſcarce be conceiv'd. Theſe ſimple or ſmalleſt particles cohering by the ſtrongeſt force or attraction, compoſe bigger particles of feebler virtue; and many of theſe cohering, compoſe other particles ſtill bigger, and more weakly united: and ſo on for divers ſucceſſions, till the progreſſion end in the biggeſt particles, on which the colours of natural bodies, and the operations in chemiſtry depend; which, by cohering, compoſe maſſes, or bodies of a ſenſible magnitude. *Newton. Optic.* p. 364, & 370.

From

From all which it appears, that the elements of gold are immutable; ſo that art goes no farther than to compounds.

Nor can the wiſdom of the ſupreme Being be ever enough adored, in creating the elements ſo firm and unchangeable; otherwiſe, the whole viſible world had by this time been changed into quite another form ||. *Helmont* himſelf aſſerting a radical ſolution of parts, ſeems to confirm this doctrine: for, ſays he, " *Deſperata ulterior mutatio, quia non invenit cui* " *miſceret.*"

*Chemical changes reducible to two kinds.*

Now, the changes of motion which chemiſtry produces in bodies, are reducible to two kinds; *viz.* an *union* of parts, and a *ſeparation* of the ſame. Thus, chemiſtry ſeparates ſpirits, ſalts, oils, *&c.* from bodies; and again unites, or compounds them together.

*Nature of a chemical operation.*

A chemical operation, then, conſiſts in changing the ſituation of the parts; particularly, either in moving ſome parts, but not the whole; which is call'd *ſeparating*; or in adding new parts, which is call'd *uniting*.

*Operations reducible to two kinds.* *Solution.* *Coagulation.*

All *chemical operations*, therefore, are reducible to two kinds; *viz.* ſuch whereby the parts of bodies, before joined and united, are ſeparated from each other; which is call'd by the antient chemiſts, *ſolution:* And ſuch whereby the parts before disjoined, are combined, or united; which is call'd *coagulation.*

And hence, chemiſtry may be defined, *the art of changing bodies by ſolution, and coagulation.* In effect, chemiſtry in all its latitude is *either the ſeparating of parts before united, or uniting parts before ſeparated,* i. e. *either the adding of bulk to bulk, or ſeparating of bulk from bulk.*

Some, however, object *digeſtion*, as a third ſpecies of operation, not reducible either to *union* or *ſeparation*; the maſs, in this caſe, being ſuppoſed to remain the ſame as before: Thus, ſay they, if you take aloes, myrrh, and ſaffron, and pouring ſpirit of wine upon them, digeſt them for the ſpace of a month, to make an elixir; there is neither union nor ſeparation made; but the maſs is the ſame, without either addition or diminution. To which we anſwer, that there is both a ſeparation, and a new union or compoſition; for the ſulphurous part of the ſpirit of wine is evidently united with the parts of the aloes, myrrh, and ſaffron: And in

|| To this purpoſe, the philoſopher laſt mention'd, cloſes a fine inquiry into the nature, laws, and conſtitution of matter— " All theſe things conſider'd, it ſeems " probable to me, that God, in the be" ginning, created matter in ſolid, maſ" ſive, hard, impenetrable, moveable par" ticles—incomparably harder than any " of the porous bodies compounded of " them: nay, ſo hard as never to wear, " or break in pieces; no human power " being able to divide what God made " one, at the creation. While theſe par" ticles continue entire, they may com" poſe bodies of one and the ſame na" ture and texture in all ages: but " ſhould they wear away, or break in " pieces; the nature of things depending " on them, would be changed; water, " and earth, compoſed of old worn par" ticles, and fragments of particles, would " not be of the ſame nature now, as wa" ter and earth compoſed of intire par" ticles at the beginning. And therefore, " that nature may be laſting, the changes " of corporeal things are to be placed on" ly in the various ſeparations, and new " aſſociations and motions of theſe per" manent particles." *Newton. Optic.* p. 375, 376.

order

order to this union, there muſt firſt be a ſeparation; *i. e.* the juice of the aloes is ſeparated from the veſſels it was before contain'd in; and out of the *ſtamina* of the ſaffron is drawn an oily matter, to be mixed with the ſpirit of wine; leaving an inſipid inodorous earth behind.

Some ſtill think the diviſion too ſimple; and ſubdivide it into a number of particular operations; as *calcination*, *vitrification*, *ſublimation*, *fermentation*, *putrefaction*, *&c.* all of which do really come under the two general heads abovementioned.

*Calcination, ſublimation, &c. reducible to ſeparation.*

Thus, *calcination* is only a ſeparation of all the fluid parts from the ſolids; after which, all that remains, is earth: or, calcination is the union of the ſalts, and earth. So alſo *ſublimation* is a ſeparation of the volatile parts from the fixed, *&c.*

*Effect of chemical operation.*

But, as to the effect of the *chemical ſeparation*, there is ſome diſpute among the chemiſts: the generality will have it a diviſion of the bodies into ſuch leſſer bodies or corpuſcles, as they before conſiſted of: ſo, as the ſeparation does not make any body exiſt, which had not an exiſtence before.

*The parts of bodies hereby render'd different from what they were.*

But others, and with good reaſon, hold, that all our operations, in ſeparating the parts, do really render them different from what they were, when united; and that the corpuſcles, or *principles* we reſolve them into, did not exiſt ſuch before the operation. Thus, ſay they, diſtil wine over and over, and you will ſucceſſively get ſpirit of wine, vapid water, ſubacid water, a more acid water, oil, bitter yellow ſpirit, and a *caput mortuum*, which is reſolvable into earth, oil, *&c.* Now, do not ſay you have reſolved the wine into its component parts: for if you remix theſe elements, you will thereby have a deteſtable maſs, vaſtly different from the primitive wine.

Again, diſtil wine, or the juice of the grape, with all your art, and you will never get out any ſpirit of wine; but add ſome ferment, or barm, and the alcohol will readily riſe. Again, when plants are burnt, there always remains a fixed ſalt in the earth, or veſſels; how vehement ſoever the fire have been: but if thoſe plants have putrified a little, the ſalts are all volatile. Whence it appears paſt doubt, that ſome of our operations make a great change in the bodies *.

Again,

* Mr. *Boyle*, in his *Sceptical Chemiſt*, furniſhes abundance of curious things on the chemical principles, or *elements*. Fire, he clearly proves, does not barely take the elementary ingredients of bodies aſunder, but alſo alters them; and ſubſtances are thereby ſeparable from bodies, which were not pre-exiſtent therein: we don't mean materially pre-exiſtent; but only in that form: nor even that ſome things may not be procured from mix'd bodies that were more than barely materially pre-exiſtent; but only, that ſeveral things obtain'd from a mixed body, expoſed to the fire, were not its ingredients before; and that the ſubſtances called principles, may be produced, *de novo*, various ways. In order to this, he obſerves, that the operation of fire does ſometimes not only divide mixed bodies into minute parts, but alſo compounds thoſe parts after a new manner; whence there may reſult as well ſaline, and ſulphurous ſubſtances, as thoſe of other textures. Thus ſoap, which

*Bodies not reduced to their first elements.* Again, the chemists usually teach, that by their operations, bodies are resolved to their first component principles, or elements: but this is a delusion: We do not, cannot make any such separation. For by *element* *, is understood such a minute, simple, homogeneous corpuscle, as is not capable

is known to be an artificial composition of oil or grease, salt and water incorporated together, being exposed to a gradual fire in a retort, will separate, but not into the same substances whereof it was compounded; but others, of a very different kind. Add, that from many vegetables, there may, without any addition, be procured glass, a body surely not pre-existent in them, but produced by the fire: And from mercury, by a proper management, a fourth part of clear water may be procured; tho' tis no way possible any such quantity of water should be contain'd in a fluid fourteen times heavier than water: How, then, can we be sure that phlegm is barely separated, not produced in other bodies by the action of fire; for we know of but few, if any bodies, of a more unalterable nature than mercury. To say no more, a vegetable may be nourish'd, and grow up of water alone; and such vegetable, by a common analysis, yield all the principles: Now, if out of fair water alone, not only spirit, but salt, oil, and earth may be produced; it follows, that salt and sulphur, &c. are not primogeneal bodies and principles; since they are daily made out of plain water, by the texture which the seed, or seminal principle of plants, gives it. Nor would this seem so strange, did not we overlook the obvious, and familiar operations of nature: for if we consider, what slight qualities they are, that serve to denominate a chemical element; we shall find, that nature frequently produces as great alterations in several portions of matter. To be readily dissoluble in water, is enough to make a body pass for a *salt*: yet we see not why, by a new arrangement, and disposition of component particles, it should be harder for nature to compose a body dissoluble in water of a portion of matter that was not so before, than of the liquid substance of an egg, which will easily mix with water, to produce, by the bare warmth of a brooding hen, membranes, tendons, feathers, &c. not dissoluble in water. See the article *Fire*.

* Agreeably to this definition, *elements* or *principles* are defined by M. *Homberg* to be the most simple matters into which a mixed body is reducible by chemical analyses: but the chemists do few of them use the word with so much reserve; chusing rather to conceive, and speak of *elements* as the very primary corpuscles whereof mixed bodies are composed: A way of conceiving, which subjects them to infinite difficulties, and is the foundation of a good part of the objections made against them by Mr. *Boyle*.

The antient chemists allow but of three elements; *viz. salt*, *sulphur*, and *mercury*; which they more emphatically call *hypostatical principles*, or the *tria prima*. To which the moderns have added two more, *viz. water* and *earth*.

These principles took their denomination from certain qualities observed in the several substances procured in analyzing of bodies by fire: an inflammable substance rising, that would not mix with water, they call *sulphur*: what comes over sapid, and dissoluble in water, passes for *salt*: what is fix'd, and indissoluble in water, they name *earth*: and all the volatile substances, *mercuries*. Or thus,

A body, in distillation, usually separates into volatile, and fixed parts; and those volatile parts either ascend in a dry form, which, if it be sapid, they call *volatile salt*; or in a liquid form; which liquor is either inflammable, and so passes for *sulphur*, or *oil*; or not inflammable, and yet subtile, and pungent, call'd *mercury*, or *spirit*; or else insipid, term'd *phlegm*, or *water*: for the fixed part, it usually consists of particles, partly soluble in water, and sapid; which therefore make *fixed salt*; and partly insoluble, and insipid, call'd *earth*.

The distinct offices of each in the composition of bodies, they thus assign: Salt is the basis of solidity and permanency; that this may be dissolved into minute parts,

pable of being further divided, diminiſhed, or changed by any operation yet known. Thus, if we did not know any way of changing ſpirit of wine, ſo as to make it any other thing; or of changing the particles of mer-

parts, and convey'd to the other elements, there is a neceſſity of water: and that the mixture may not be too rigid, and brittle, a ſulphurous or oily principle muſt intervene, to make the maſs more tenacious: To this a mercurial ſpirit muſt be ſuperadded, which, by its activity, may permeate, and, as it were, leaven the whole maſs, and thereby promote the more exquiſite incorporation of the ingredients. To all theſe a portion of earth muſt be join'd, which, by its dryneſs, and poroſity, may ſoke up part of the water wherein the ſalt was diſſolved, and concur with the other ingredients, to give the body the requiſite conſiſtence.

Theſe principles are uſually divided into *active* and *paſſive*; the active are the *tria prima*, or three hypoſtatical principles; the paſſive are earth and water, which are alſo call'd *elementary* principles. But M. *Homberg* has reform'd this diviſion: ſulphur he makes the only *active* principle; earth the only *paſſive* one; and all the reſt *intermediate* principles. Sulphur is the active principle, in regard, according to him, 'tis this alone that acts of itſelf, and that makes all the reſt act. Earth is denominated a paſſive principle, as it never acts, but ſerves merely as a matrix or receptacle of the other principles: And ſalt, water, and mercury, are call'd *intermediate principles*, becauſe they do not act of themſelves, and yet become capable of acting, by their being join'd with ſulphur, which modifies them, and is modified by them a thouſand ways. *Mem. de l'Acad. An.* 1702.

Mr. *Boyle* attacks the common doctrine of the chemical elements, with admirable force and addreſs; making appear, that the different ſubſtances into which mix'd bodies are commonly reſolved by fire, are not of a pure and elementary *nature*; but retain ſo much of the concrete that afforded them, as to appear ſtill compounded; and often to differ in one concrete from principles of the ſame denomination in another: that, as to their *number*, it is not preciſely three, as the chemiſts have uſually maintain'd; becauſe in moſt vegetable, and animal bodies, earth and phlegm are alſo found; but that there is no one determinate number into which the fire univerſally reſolves all compounds, mineral and others: And that there are ſeveral qualities which cannot be refer'd to any of theſe ſubſtances, as if they primarily reſided therein; there being, withal, other qualities, which, tho' they ſeem to have their chief, and moſt ordinary reſidence in one or other of theſe principles, are not yet ſo deducible from it, but that more general principles may be taken in. *Sept. Chym.*

It may be alledged, that bodies are only call'd ſalt, ſulphur, mercury, *&c.* on this footing, that the principle of the ſame is predominant therein; but it does not even appear, that the reputed ſalt, ſulphur, or mercury, principally conſiſts of one ſimple body to give it that denomination; or that there is any ſuch primitive, ſimple ſubſtances exiſting in the bodies whence theſe are procured. If it be demanded, then, what it is that the chemical analyſes of bodies do prove? We anſwer, that mixed bodies included in cloſe veſſels, are reſoluble into ſeveral ſubſtances different in ſome qualities, but chiefly in conſiſtence: ſo that out of moſt bodies may be obtain'd a fixed ſubſtance, partly ſaline, and partly inſipid; an unctuous liquor; and another fluid, or more, which, without being unctuous, have a manifeſt taſte. Now, if the chemiſts will agree to call the dry and ſapid ſubſtance, *ſalt*; the unctuous liquor, *ſulphur*; and the other *mercury*; we have nothing to object: But if they will obtrude this ſalt, ſulphur, and mercury on us, as ſimple, and primary ſubſtances, whereof each mixt, is actually compounded, and which were really therein antecedent to the operation of the fire; they go further than their experiments will bear them out. And as an element ought to be perfectly ſimilar, and homogeneous; there is no juſt cauſe why we ſhould give a body

mercury, but they ſhould ſtill be mercury: we might call theſe, *elements.* But do the chemiſts bring all bodies to ſuch elements? No: for there is no

propoſed the name of any particular element or principle, becauſe it bears a reſemblance thereto in ſome obvious quality, rather than deny it that name, on account of ſeveral other qualities, wherein it is unlike. *Boyle, ubi ſupra.*

The chemiſts will not allow the ſalt in aſhes to be call'd *earth*; notwithſtanding that the ſaline and earthy parts correſpond in many reſpects; *e. gr.* weight, dryneſs, fixedneſs, and fuſibility; for this only reaſon, that the one is ſapid, and diſſoluble in water, and the other not: beſide, that ſapidneſs and volatility denominate the chemiſts *ſpirit*, or *mercury.* And yet, how many bodies may happen to agree in thoſe qualities, which have different natures, and divers diſagreeing qualities?

For not only ſpirit of nitre, *Aqua fortis*, ſpirit of ſalt, oil of vitriol, ſpirit of alum, ſpirit of vinegar, and all ſaline liquors diſtil'd from animals; but all acetous ſpirits of woods, muſt belong to their mercury: tho' it does not appear why ſome of theſe ſhould rather come under that denomination, than the chemiſts ſulphur, or oil; for their diſtill'd oils are fluid, volatile, and ſapid, as well as their mercuries. Nor is it neceſſary that ſulphur ſhould be unctuous, or indiſſoluble in water; ſince ſpirit of wine is generally refer'd to ſulphurs, tho' it be not unctuous, and will readily mix with water. So that nothing but bare inflammability is left to conſtitute the eſſence of the chemiſts *ſulphur*; as the contrary, join'd with any taſte, entitles a diſtill'd liquor to their *mercury.* Now, ſince ſpirit of nitre, and ſpirit of hart's-horn will boil together, hiſs, and throw up one another into the air, which the chemiſts allow for indications of great contrarieties in bodies; ſince I have obtain'd two ſorts of oil from the ſame parcel of human blood, which would not mix with one another; and ſince we meet with numerous inſtances of other contrarieties in bodies, which, according to the chemiſts, muſt be huddled up together, under one denomination: It may be worth conſidering how far ſuch a multitude of ſubſtances, as may agree in theſe ſlight qualities, and yet diſagree in others, deſerve to be call'd by the ſame name of a principle, rather than have ſuch appellations as diſtinguiſh them from bodies they differ ſo much from.—When, unable to ſhew that a liquor is, for example, purely ſaline; they prove, that at leaſt ſalt is the predominant principle therein, from this conſideration, that it is ſtrongly taſted; and that all taſte proceeds from ſalt: whereas ſpirits, as of tartar, hart's horn, *&c.* which are reputed the mercuries of the bodies that afford them, have manifeſtly a ſtrong and piercing taſte. And indeed, if taſte belong not to the ſpirit, or mercurial principle of vegetables, and animals; we ſcarce know it will be diſtinguiſhed from their phlegm; ſince, by the abſence of inflammability, it muſt be diſtinguiſhed from ſulphur. Add, that not only the ſpirits of vegetables, but their oils, are very ſtrongly taſted; and the moſt elaborate depuration will ſcarce ever reach to make them taſteleſs.——Again, volatile ſalt of hart's-horn, *&c.* is very ſtrongly ſcented, notwithſtanding that moſt chemiſts deduce odours from ſulphur, and from them argue the predomancy of that principle in the odorous body.——From the whole, it appears how diſſimilar each of thoſe bodies are which the chemiſts call the ſalts, ſulphurs, or mercuries of the bodies which yield them; as if they had all a ſimplicity or identity of nature: whereas ſalts, for inſtance, if they were all elementary, would differ as little as the drops of pure and ſimple water: So that we have no poſitive knowledge of the chemical principle ſulphur, by means of analyſes, or the de-compounding of mixts. This led M. *Homberg* to imagine, that ſomething might be learn'd of it from compoſitions, or artificial mixts: The effect of a great number of operations of which kind, gave him indications, that 'tis light or fire is the real principle ſulphur, and the only active matter in all mixts. So that we muſt refer the diſquiſition into the nature, properties, *&c.* of *ſulphur*, to the article of *Fire.*

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no operation yet diſcover'd, which leaves a body out of a capacity of being further changed †.

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Indeed it ſhould be expreſs'd, what kind of diviſion by fire is to determine the number of elements; for the ſame body, *e. gr. guaiacum*, which, burnt in an open fire, only reſolves into two, *viz.* aſhes and ſoot; if diſtill'd in a retort, diſſolves into oil, ſpirit, vinegar, and water and charcoal; the laſt of which, by a further degree of fire, in a cloſe veſſel, falls into aſhes, *i. e.* into ſalt and earth; and by a farther yet, into glaſs. If, then, oil paſſes for an element, becauſe producible by one degree of fire; why is not glaſs? There are ſome mix'd bodies, from which it does not appear that any degree of fire will ſeparate any of the common elements; ſuch is gold, and perhaps alſo ſilver, *Venetian* talc, oſteocolla, and glaſs; which, tho' made of a pure colliquation of the ſalt and earth remaining in the aſhes of a burnt plant; yet will ſo far reſiſt the violence of fire, that it has been held more irreducible than gold: But if an artificer can unite ſuch comparatively groſs particles, as thoſe of earth and ſalt, into a body indiſſoluble by fire; why may not nature aſſociate in ſeveral bodies the more minute elementary corpuſcles, too firmly to let them be parted by fire? There are ſome bodies whoſe component principles are ſo minute, and ſo firmly united, that their corpuſcles need leſs heat to carry them up, and diſſipate them, than is requiſite to divide them into their principles. And hence it is, that the common ſulphur becomes ſo difficult to decompound. *Boyle Scept. Chym.*

We have no evidence, that three is preciſely and univerſally the number of the diſtinct ſubſtances or elements, into which all mix'd bodies are reſoluble by fire: If it be granted, that the elements at firſt conſiſted of certain ſmall primary coalitions of the minute atoms, or particles of matter, into corpuſcles very numerous, and like each other; it will rather appear, that ſuch primary maſſes may be of far more ſorts than three, or five: and, conſequently, we need not ſuppoſe that in every compound body there ſhould be found juſt three ſorts of ſuch primitive coalitions. It is impoſſible but that two ſorts of elementary bodies may ſuffice; as we ſee is the caſe in that durable ſubſtance, glaſs; while others conſiſt of three, another of four, another of five, &c. Nay, it does not ſeem impoſſible, but there may be two, or more ſorts of mixts, which have none of the ſame elements as the other: as we often ſee two words, whereof the one has not any of the letters in the other; or, as happens in electuaries, wherein no ingredient, except ſugar, is common to any two of them. And this is confirm'd by chemical experiments: For as from ſome bodies, *e. gr.* gold, even three principles cannot be procured; ſo from others, *e. gr.* grapes, variouſly managed, may be procured at leaſt a dozen.

† Fire, even when it does divide a body into ſubſtances of various conſiſtences, does not commonly analyſe it into hypoſtatical principles; but only diſpoſes its parts into new textures, and thereby produces concretes of a new, indeed, but of a compound nature: And there are many diſtinct ſubſtances obtainable from ſome concretes without fire, which no leſs deſerve the denomination of elementary, than thoſe extorted by fire. In reality, different degrees of fixity, and volatility, ſeem to have a great effect in the producing of different elements. For, that fire frequently divides bodies on this only account, that ſome of their particles are more fixed than others, tho' either of the two be all the while far from pure and elementary, is obvious in the burning of wood, which the fire ſeparates into ſmoke and aſhes; the former of which, confeſſedly conſiſts of two ſuch different bodies as earth and ſalt; and the latter, condenſed into ſoot, diſcovers itſelf to contain ſalt, oil, ſpirit, earth, and phlegm; all which being almoſt equally volatile in that degree of fire which forces them up, are carried away together. Beſide, if two different bodies, united into one maſs, be both ſufficiently *fixed*; the fire finding no parts volatile enough to be carried up, makes no ſeparation at all. *Boyle ubi ſupra.*

*Chemical elements.* *Compound bodies; instanced in Phlegm.*

Chemiſtry, then, does not reſolve bodies into *pure, ſimple, immutable elements*; for *phlegm, ſpirit, ſalts*, and *oils*, into which bodies are uſed to be reſolved thereby, may be changed and further reſolved: thus,

1°, *Phlegm*, drawn by diſtillation from vegetables, does always carry with it ſomewhat of the ſmell of the vegetable, which it derives partly from the *oil*, and partly from the *ſpirit* reſiding therein. The ſame *phlegm*, by frequent diſtillation, lays aſide moſt of this ſmell, and approaches nearer to pure water; but never becomes perfectly ſuch. Add, that the pureſt diſtill'd water, if expoſed a few days to the ſun, is much changed, and render'd turbid *.

2°, *Spirits*,

It does not appear that all mixtures are of elementary bodies; but rather, that there are ſeveral compounds even in regard of their ingredients conſider'd antecedently to their mixture: for tho' ſome may be made up of the immediate coalitions of the elements, or principles themſelves; yet others, are mix'd at ſecond hand: now if a compound conſiſts of ingredients not merely elementary; 'tis eaſy to conceive, that the ſubſtances into which fire reſolves it, tho' ſeemingly homogeneous, may be of a compound nature; thoſe parts of each body that are moſt akin, aſſociating themſelves into a compound of a new kind. Thus, out of diſtill'd liquors, which are reputed the elements of the bodies whence they are drawn, *viz.* oil of vitriol, and oil of turpentine; the ſame author, without any addition, procured a third, *viz.* a true, yellow, inflammable ſulphur, the two liquors afterwards remaining diſtinct: and from the ſpirit of boxwood, highly rectified, he procured an acid liquor, that would diſſolve coral; leaving a ſpirit of a very different nature from the common ſpirit of that wood: ſo that at leaſt, ſome of the elements, are far from an elementary ſimplicity, and may be ſtill look'd upon as mix'd bodies. Add, that as there may be more elements than 5 or 6; ſo the elements of one body may be different from thoſe of another: whence it follows, that from the reſolution of compound bodies, there may reſult mixtures, wholly of a new kind, by the coalition of elements, perhaps never convened before. *Ib.*

*Helmont* gives us a way of converting oils of cinnamon, blood, harts-horn, or the like, wholly into volatile ſalts, by a bare mixture of their own alcaline ſalts: if, then, ſuch ſaline volatile ſubſtances, which paſs for elementary, be producible of chemical oils, and fix'd ſalts, the one made volatile by the other, and both aſſociated by the fire: it may well be ſuſpected, that other ſubſtances, ariſing from the ſeparation of bodies, by fire, may be new ſorts of mixtures, and conſiſt of ingredients of different natures. Thus, particularly, I have ſometimes ſuſpected, that ſince the volatile ſalts of blood, harts-horn, &c. are fugitive, and of an exceeding ſtrong ſmell; 'tis either an error to aſcribe all odors to ſulphurs; or that ſuch ſalts conſiſt of ſome oily parts, well incorporated with the ſaline ones: and the like conjecture I have alſo made, as to ſpirit of vinegar, which has a piercing ſmell. *Id. ibid.*

* That *phlegm* is not an elementary body, appears from its different powers and properties: the phlegm of wine, and moſt liquors, have qualities, that make 'em differ both from mere water, and from one another: the phlegm of vitriol, Mr. *Boyle* obſerves, is an effectual remedy againſt burns; and a valuable noſtrum for diſcuſſing hard tumours: that of vinegar will extract a ſaccharine ſweetneſs out of lead, and even diſſolve corals with long digeſtion: that of ſugar of lead, is ſaid to diſſolve pearls. *Scept. Chym.*

The characters which ſerve to denominate a fluid *phlegm*, or *water* among the chemiſts, are inſipidity, and volatility; yet quickſilver has both theſe, which no body pretends to be phlegm. Add, that it appears from ſeveral experiments, that water it ſelf, by repeated diſtillations, may be converted into earth. *Boyle*'s *Producib. of Chym. Princip.*

Water has a much fairer pretence to be an element, than any of the *tria prima*: the chief qualities that occaſion men to give that

2°, *Spirits*, how simple, and immutable soever they may appear, are yet capable of being decompounded: for, the most simple, highly rectified *spirit* of wine, call'd *alcohol*, which uses to burn quite out, without leaving any fæces at all, is yet found to consist of an acid, and a greatly attenuated oil; and if it be digested with salt of tartar, does half of it turn into water: the remaining spirit, at the same time, becoming so weakened by the salt, as to lay aside its hot, fiery taste. Indeed it must not be omitted, that as there is air in all vessels, wherein spirits are raised, and caught; and as along with air, there is always intermix'd water, and divers other bodies; 'tis no wonder that the spirit should not be found perfectly simple, nor that it is impossible perfectly to purge the spirit of all its water or phlegm †. *Spirit.*

3°, *Salts*,

that name to any visible substance, are, that it is fluid, insipid and inodorous: but we have never seen any of those separated substances, chemists call phlegm, perfectly destitute both of taste and smell. Common salt, and several other saline bodies distilled ever so dry, will each yield a large quantity of phlegm; which can be no other way accounted for, but from this, that among the various operations of the fire, on the matter of a concrete, several particles of that matter are reduced to a shape and size, requisite to compose such a liquor as the chemists call phlegm or water. *Scept. Chym.* See farther in the article of *Water*.

† The name *spirit* is applied by the chemists to several very different substances: it denotes in the general, any distilled, volatile liquor, that is not insipid as phlegm, nor inflammable as oil: but under this general idea, are comprehended liquors of quite opposite natures, some being *acid*, as spirits of nitre, salt, and vinegar; and others *alcalious*, which are such enemies to the former, that as soon as they are put together, they tumultuate and grow hot: To which may be added a third kind, call'd *vinous*, or inflammable, which tho' very subtle and penetrating, are not manifestly either acid or alcaline.

All these sorts of spirits Mr. *Boyle* shews to be producible: and 1°, The *vinous*, which nature scarce ever produces of herself; fermentation being requisite thereto. 2°, *Alcalious* spirits call'd also *urinous*, by reason of their affinity in many qualities with spirit of urine, are manifestly not simple, but compound bodies, consisting of the volatile salt of the respective concretes dissolved in the phlegm, and for the most part accompanied with some little oil; so that these may be referr'd to the article of volatile salts. 3°, *Acid* spirits appear to be producible hence, that those drawn from common salt and nitre, are very different in respect of taste, &c. from the bodies they are procured from, which are not properly acid: so that it does not appear, that the spirits pre-existed in that state, in those bodies. What further confirms the whole, is, that the same body, merely by different ways of ordering it, may be brought to afford either acid, vinous, or urinous spirits. *Boyle Scept. Chym.*

Add, that whereas salt is laid down as the principle of all taste; and bodies are argued to be *saline* for this reason, that they are sapid, 'tis implied in the very notion of a spirit, that it have salt along with it; it being its taste that characterizes, and distinguishes it from phlegm, and denominates it acid, vinous, or urinous spirits. *Boyle's scept. chem.*

As to mercury, which is spoke of by chemists as a principle, near a-kin to spirit, or rather is confounded therewith: its characters, as delivered by writers, are, to be a fluid substance, or volatile liquor, which distinguishes it from the saline principle, especially fixed salts; and not inflammable, which distinguishes it from sulphur or oil. But, as this leaves it undistinguished from phlegm; others add another quality, *viz.* taste, which is wanting in phlegm, which brings the chemical mercury precisely to what we call a spirit. The *mercuries* of vegetables and animals, therefore, are already spoke of as *spirits*.

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Salt. 3°, *Salts*, tho' they ſeem perfectly ſimple, yet when rectified, yield either an acid, or an *alcohol*, and *phlegm*; and if the diſtillation be repeated, do ſtill become purer, and purer, leaving every time a quantity of oily fæces behind 'em; and at length, loſing all their ſaline quality, become inſipid. Thus, ſalt of tartar, which by a violent combuſtion in the fire, an intimate ſolution in water, and a filtration, ſhould ſeem perfectly purified; yet if it be diſſolved *per deliquium*, leaves a large earthy ſediment: and if the oil of tartar, thus prepared, be dried again, and the ſalt-juice be calcined, and ſuffered to diſſolve again *per deliquium*; it will leave ſtill more earthy fæces. And if the operation be repeated a good number of times, the ſalt will at length be all converted into earth.

All ſalts conſiſt of fix'd, and volatile parts; and human ſalts, particularly, reſolve, by diſtillation, into an oily ſpirit, and earth: nor does it appear, that the chemiſts ever get a ſalt quite clear of oil; for all volatile ſalt has ſome ſmell; but that ſmell ariſes only from the oils therein *.

4°, *Oils*,

The mercury of foſſils, or metals, is no other than a real running quickſilver; which is a fluid ſubſtance, perfectly reſembling a metal in fuſion, nearly of the ſame weight with ſilver, and wetting no body but gold. This body not being reducible into more ſimple matters, by any analyſis yet invented, is look'd upon as a principle: 'tis commonly held it may be extracted, or obtained from all metals and minerals. And the chemiſts, in their writings, give us divers proceſſes for the ſame; tho' the more judicious, and ſober among them, have long look'd on the pretenſion as idle, and chimerical.

But this principle, *mercury* or quickſilver, M. *Homberg* gives us ſufficient reaſon to ſuſpect not to be ſimple; in that it may be deſtroyed, which a body perfectly ſimple cannot. Add, that after its deſtruction, there remains nothing but a mere earthy matter, without any ſigns of the other parts before compounded with it. The method that author took to deſtroy it, was by firſt changing the running mercury into a perfect metal, gold, by introducing a ſufficient quantity of the rays of light into its ſubſtance, by a long and expenſive operation; and when it was thus rendered a metal, by expoſing it to a burning glaſs, which in a little time carried off the greateſt part of its ſubſtance in fumes, leaving nothing behind but a light earthy duſt. *Mem. de l'Acad. R. An.* 1709. See further under the article *Mercury*.

* *Salt* ſeems the leading principle of the chemiſts, who generally grant ſalts the moſt conſiderable and active parts procurable by chemiſtry from mixt bodies. Its character is to be ſoluble in water, and unreſoluble by fire; but, under this character it is incapable of being perceived by us; and needs to be joined or combined with ſome other principle, to make it ſenſible.

We have three kinds of ſalts, two whereof are volatile, and the third fix'd; the volatile are *acid* and *urinous* ſalts, the fix'd *lixivious*, or thoſe drawn from aſhes: the two latter are alſo call'd *alcalious* ſalts, or *alcalies*, the one volatile, the other fix'd. We do not know the preciſe figure of each of theſe ſalts; but to judge of 'em from their effects, the moſt commodious and probable, according to M. *Homberg*, the great reformer of the doctrine of ſalts, is, for *acids*, to be pointed, and thoſe points tipped with ſulphurous matter; that of urinous ſeems to be a ſponge, containing a part of the acid, and a little fœtid oil; that of lixivious ſalts, appears likewiſe, a ſponge, containing only the remainder of the acid, which the calcining fire could not carry off.

1°, If *acid ſalts* were found pure, and without any mixture, they would all be of the ſame nature; and the diverſity that appears in 'em, as procured by diſtillation, &c. is a full proof of their being compounds, at leaſt of their having ſomething

4°, *Oils*, by diſtillation reſolve into an *oil*, an *acid ſalt*, and *water*; and the oil diſtilled ever ſo often, does always leave earth behind it; ſo as, at length, Oil.

thing heterogeneous, or adventitious to the ſaline nature accompanying them. In effect, ſulphur, on M. *Homberg*'s principles, is a conſtant and inſeparable attendant thereof: from this appendage of ſulphur, it is, that they derive all their activity; and 'tis the ſame ſulphur that characterizes, and makes the difference between 'em. Hence acid ſalts are rang'd by the author, into three claſſes, *viz.* ſuch as contain an animal or vegetable ſulphur; under which come all the acids diſtill'd from plants, fruits, woods, &c. and ſpirit of nitre: ſuch as contain a bituminous ſulphur; to which belong the acid ſalts of vitriol, common ſulphur, and alum: and ſuch as contain a more fix'd mineral ſulphur; as the acids drawn from ſea ſalts, and ſal gems.

Thoſe of the firſt claſs, act more ſwiftly than thoſe of the other, by reaſon animal, and vegetable ſulphurs being very light, *i. e.* taking a deal of room, and enlarging the ſurface, give the better handle to the flame to agitate and drive 'em on; but the ſame enlargement of the points, prevents their entering into the denſer and more compact bodies: thoſe of the ſecond claſs are the leaſt nimble, by reaſon the bituminous ſulphur is loaden with a deal of earth, which ſerves it as a matrix; and accordingly, theſe are incapable, ſingly, of diſſolving metallic bodies. Laſtly, the metallic ſulphur, being the moſt fix'd, *i. e.* its parts the ſmalleſt and moſt compact, the acids it accompanies, do ſtill retain fine points, and thereby become capable of inſinuating into the denſeſt bodies, and ſeparating 'em: tho' for the ſame reaſon they give but little hold to flame.

Acid ſalts join'd with *lixivious* ones compoſe mix'd or intermediate ſalts, according to the nature of the acids employed therein. *V. gr.* ſpirit of nitre, with ſalt of tartar, produces true ſalt-petre; ſpirit of ſalt, with ſalt of tartar, produces true common ſalt; ſpirit of vitriol, with ſalt of tartar, produces true vitriol, &c. which are all intermediate ſalts, *i. e.* partly fix'd, and partly volatile, the two ingredient ſalts ſtill retaining their volatile and fix'd natures. *Acids* join'd with *urinous* ſalts, compoſe another ſort, call'd *ammoniac* ſalts, which are always volatile, by reaſon both the ingredient ſalts are ſo. *Acid ſalts*, are uſually ſuppoſed to be antagoniſts to *alcalious*, (*i. e.* urinous and lixivious) by reaſon, upon their mixture, there always enſues a violent ebullition, and effervеſcence; but it would, perhaps, be more juſt to look on this ebullition not as a combat, but rather a ſuitable and amicable conjunction of two ſubſtances, which were naturally united, and had only been ſeparated by the violence of the fire, now reſtoring themſelves into the ſame places, out of which they had been torn. Accordingly, the latter are compared to ſheaths, and the former to points or ſpicula fit to enter the ſame. Theſe points or acids do not only enter the pores or ſheaths of alcaline ſalts, but all other bodies, whoſe pores have a like conformation; whence ſuch bodies are call'd terreſtrial or metallic alcalies. *Mem. de l'Acad. An.* 1702. See more on the ſubject of acid ſalts, in the article *menſtruums.*

2°, In all native ſalts, both foſſil, vegetable and animal, after the violence of the fire has ſeparated all the volatile parts, there ſtill remains a *fix'd* ſalt, to be drawn from the fæces by lotion, or lixiviation; hence call'd a lixivious ſalt. Theſe *lixivious* ſalts are no other than the relicks of the *acid*, which the fire was not able to ſeparate from the earth of the mixt, but may be ſeparated by diſſolving 'em in common water. The taſte of theſe lixivious ſalts is very different, according to the quantity of the acid ſtill remaining after calcination: part of which is capable of being volatiliz'd, and diſengag'd by further operations; as by a more intenſe heat; or by diſſolution, digeſtion, filtration, and evaporation frequently repeated; or laſtly, by adding ſome urinous ſalt, to abſorb the ſame.

3°, We have three ſorts of *urinous* ſalts: the firſt, that of plants, or animals, which is the ſame; the ſecond is foſſil; and the third of an intermediate kind, partaking both of

of the fossil and vegetable nature; the first is volatile, and the two latter fix'd. By *urinous* salts, we mean all such as partake of the taste or smell of urine. Their effect in volatilizing fix'd salts is notorious: for being added to common salt, there arises, by fire, a salt of a volatile kind, called a sal ammoniac. Tho', for volatilizing the fix'd salts of plants, the urinous salts of plants are not so proper as the urinous salts of the intermediate class, such as alum: and for the fix'd salts of fossils, the fossil urinous salt is fittest, *viz.* borax. *Homb. ubi supra.*

All the sorts of salts, then, do throughout, appear, avowedly *compound*, and unelementary: and that they are likewise *producible*, *de novo*, and *convertible* into one another, is strenuously argued by Mr. *Boyle*. The two chief qualities, wherein they all agree, and which therefore make up the common received notion of salt in general, he observes, are to be easily dissoluble in water, and to affect the palate so as to cause a sense of taste. Now, since the invisible particles, which compose the visible portions of a salt, may be so contriv'd as to make other parcels of matter, which have the qualities that denominate bodies *sulphurous*, or *spirituous*; as we see in nitre's being made inflammable: why may not other corpuscles, or small portions of matters not saline, be so broken into minute parts, and these so shaped and connected, as, when duly associated, to compose a body capable of dissolution in water, and of affecting the organ of taste.

That a disposition to be dissoluble in a liquor, may be acquired by mixture, and a new texture of parts, appears from many instances: and as for the taste, 'tis some question, how far the necessity thereof may consist with another principle; for the purest oils are sapid, yet will not dissolve in water; so that there does not appear any strict connection between being *sapid*, and *soluble* in that fluid. *Helmont* assures us, that by *Paracelsus*'s *sal circulatum*, solid bodies, among which he instances stones, may be transmuted into actual salt, equal in weight to the body whereof it was made; consequently, as the chemists allow of sulphur, mercury, &c. in such bodies, it appears, that the same portions of matter, which pre-existed in the form of those simple ingredients, must, by the operation of fire, and the menstruum, have been converted into salt.

For *acid* salts; we may instance in salt-petre, which, tho' it have no acid taste, may be made to afford, by distillation, above three quarters of its weight, of a highly acid liquor; yet it does not appear, that such a great proportion of acid particles, or possibly any proportion at all, is employed by nature, in the composition of nitre.

For *urinous* salts, we have an instance of their production, in the salt, obtained by distillation, from soot; for tho' the wood we burn in our chimneys, seem to have nothing of the taste or smell of urine; nor have the dissolutions of the saline parts of such wood, been observ'd to have any affinity, in taste, or odour thereto; yet when wood is burnt in the fire, and the soot afforded by it distill'd, we get a white volatile urinous salt, like what is afforded by blood urine, or the like.

For *lixivious*, or the *fix'd salts* of calcin'd bodies, the chemists themselves are not entirely agreed. For however the prevailing opinion may be, that these fix'd alcalies pre exist in mix'd bodies; *Helmont* very ingeniously proposes another origin, and holds 'em, as to their alcaline form, productions of the fire, by whose violent action, a part of the salt, which in the concrete, is all naturally volatile, laying hold of some parts of the sulphur of the same body, both become melted together, and thus fix'd into an alcali: which fixation he exemplifies, by what happens when salt-petre and arsenic, tho' both volatile, when exposed to the fire, are, by its operation flux'd and made to fix each other: tho' what seems to overthrow this account, is, that the fire may not perhaps be always found a necessary agent, in the production of a lixivious alcali: for Mr. *Boyle* tells us of a piece of true native *Egyptian* nitre, which appeared to have all the properties of a fix'd alcali. That author pursues the point further; and shews how to make alcalies from sea-salt and salt-petre, tho' confessedly acids; how alcalies may be deprived of their alcaline form, and turn'd into other substances; how common salt may be procured from sandever, a fix'd alcali, &c. *Producib. of Chem. Princip.*

length,

length, it all becomes earth *; as Mr. *Boyle* aſſures us from experiments ; and

* The chemiſts lay down inflammability as what characterizes their principle *ſulphur*: whence it happens, that three ſubſtances, manifeſtly different in conſiſtence, and texture, come neceſſarily to be referr'd to ſulphur : the inflammable ſubſtance, obtained from mixt bodies, by means of fire, appearing ſometimes in form of an oil, which will not mix with water ; ſometimes in form of an inflammable ſpirit, which will readily unite with that liquor ; and ſometimes in form of a conſiſtent body, not unlike foſſil ſulphur. Now, what in moſt mix'd bodies is call'd *ſulphur*, need not be conceived as any primordial ingredient, but rather as a generated and reſulting thing: for ſulphur it ſelf is made of the ſame univerſal matter with other bodies ; and is only a coalition of certain particles thereof, whoſe aggregate, by having a particular texture, *&c.* becomes diſpoſed to be turn'd into fire, and uſually alſo into flame ; and therefore if the like texture may be found in portions of matter, in other reſpects different, or if art and chance can frame, and bring together particles of matter ſo diſpoſed, or can give 'em ſuch a texture as diſpoſes 'em to kindle, flame, or burn away ; theſe qualifications entitle it to the nature of a ſulphur, whether it participate of the chemiſts primæval ſulphur, or not.

And, that it is not neceſſary the *oil*, procured by fire from mixts, be a primæval element, may be argued from the growth of plants, fed merely by water; which nevertheleſs afford an oil in diſtillation : and we ſee that in olive trees, almond trees, walnut trees, *&c.* the rain water, which inſinuates it ſelf into their roots, is, by ſucceſſive changes of texture, reduced into the oil, which the fruit, by expreſſion, ſo plentifully yields. And to obviate the ſuſpicion of common water being impregnated with any ſulphurous juices of the earth, it may be added, that diſtill'd water will nouriſh a vegetable. What is more, Mr. *Boyle* relates an experiment, whereby from two diſtill'd liquors, both diſſoluble in water, and both held by the chemiſts, as elementary bodies, *viz.* oil of vitriol, and alcohol of wine, he procured a conſiderable quantity of chemical oil, of a very different nature from either of the ingredient liquors. *Producib. of Chym. Prin.*

This oil, or ſulphur, of vegetables and animals, is, according to *Helmont*, reducible, by means of lixivious ſalts, into *ſoap* ; as that ſoap is, by repeated diſtillations from a *caput mortuum* of chalk, into inſipid water. *Id. Scept. Chym.*

For the production of that kind of ſulphur call'd *inflammable* ſpirits, it has already been touch'd on, in ſpeaking of *ſpirits.* For that of *conſiſtent* ſulphurs, it does not appear, that any ſuch ſubſtance is really procurable, either from vegetables or animals : what the chemiſts have uſually taken for vegetable ſulphurs, Mr. *Boyle* ſhews to be no other than foſſil ſulphurs, and to be ſeparated, not from the matter of the vegetable, but from that of the foſſil matters uſed in the proceſs. And as for the ſulphurs ſometimes obtain'd from *metals*, and *minerals*, 'tis much to be doubted whether they belong'd thereto, as eſſential ingredients, or were only corpuſcles of common ſulphur, perhaps, a little alter'd, and mingled with other parts eſſential to the mineral. Thus we ſee in native cinnabar, the mercury, which chemiſts ſuppoſe a compleat metal, is ſo mix'd with another body, as not to be diſtinctly diſcernible, till ſeparated by the fire : and from this cinnabar, ſulphur has been ſometimes obtain'd. Add, that as a large quantity of common ſulphur is eaſily ſeparable from vitriol marcaſites ; it appears poſſible for ſome common ſulphur to remain more cloſely mix'd with the ſaline and metalline parts of the vitriol, afforded by the ſame marcaſites ; from which latent corpuſcles may proceed the ſulphurous ſmell, *&c.* obſerv'd in vitriol and its oil. See *Boyle's Producib. of Chym. Princip.*

M. *Homberg* refines conſiderably on the notion of the principle *ſulphur*. That oily, or fatty matter, found in the analyſis of all plants, and animals, and ſome minerals, and which has been always taken for the chemical principle ſulphur; cannot be a principle, on his foundation ; ſince it may be

and as we our ſelves have found from a like experiment, made in oil of *guaiacum* †.

Salt

be reduced into other ſimpler matters. Add, that as he lays down the principle ſulphur for the only active one, and which of conſequence ſhould be found in all mixts; this oily matter is wanting in moſt minerals, and therefore cannot be the only active principle. In the analyſis of an oil, its whole ſubſtance reſolves into a deal of aqueous liquor, a little inſipid earth, and a little ſalt, partly fix'd and partly volatile; the real principle ſulphur, which connected theſe principles together to make an oil, is loſt in the operation; the whole ſtudy of the artiſt being only to ſeparate the principles from each other. And as the principle ſulphur is only ſenſible while join'd with ſome other of the principles, which ſerve it as a vehicle; it muſt of neceſſity eſcape from whoever would ſtrip it of all heterogeneous matter.

This ſulphur may either be conſider'd as *mingled*, and retain'd in ſome other matter; which, as it is aqueous, ſaline, earthy, or mercurial, the reſult will appear under the figure of ſpirit of wine, oil, bitumen, or metal; none of which are the principle ſulphur: or, it may be conſider'd as *pure*, and without any mixture; in which laſt ſenſe alone, it is, that ſulphur is to be accounted a principle, and the only active principle; leaving to the reſt the appellation of ſulphurous matters. Now, all mixts, that excellent author obſerves, in paſſing a rigorous analyſis, loſe the principle ſulphur, which was the band of the compoſition; ſo that the more the chemiſt endeavours to extricate, and diſengage it, the leſs he finds it.

† *Earth*, by the chemiſts call'd *terra damnata*, of all ſubſtances ſeems to have the faireſt claim to an elementary nature; in regard the violence of the calcining fire ſhould ſeem to have driven away all the mercurial and other volatile parts, and have quite burnt out the ſulphurs, which are often more fix'd than the reſt; as the water, on the other hand, ſhould have diſſolved all the fix'd ſalt: and yet, as to the characters, whereon the ſimplicity and immutability of the earthy part of bodies are ſuppoſed to depend, *v. gr.* its not diſſolving in water, its not affecting the taſte, and not having flown off with the other parts; it will be found that theſe too, are producible, may be compounded, &c.

Mr. *Boyle* has ſhewn, that not only each of theſe qualities ſeparately, but all of them together, may and frequently do, ariſe from the mixing and variouſly managing of compound ſubſtances, wherein before they were not. Thus from oil of vitriol, and ſpirit of wine, tho' both diſſoluble in water, and ſapid, he has, by digeſtion and diſtillation, procured a large quantity of a ſubſtance indiſſoluble in water, inſipid and fixed. So alſo glaſs, which tho' not only a compounded, but a recompounded body, (the ſand, and other ſtones, which themſelves are mix'd bodies being further compounded with the ſalts that diſſolve them) has yet all the three qualities, which the chemiſts require in their earth; for 'tis taſteleſs, diſſolves not in water, and is fix'd in the fire. And if aſhes be of themſelves capable of vitrification, as the chemiſts teach; how are we ſure, that in common aſhes, freed after the uſual manner, from their fixed ſalt, what is called a ſimple earth, may not be a body compounded of two, or more ſubſtances, which by their coalition, and new texture, produced by the action of the fire, have been brought to a kind of vitrification?

That earth may be produced *de novo*, may likewiſe be argued hence, that if ſalt of tartar be diſſolved in fair water, there will remain, after numerous filtrations, and after every ſingle one, a ſubſtance in the filtre, which has all the chemical characters of earth. The *terra damnata* of vitriol appears evidently no elementary body, from its purpliſh colour, its weight far exceeding that of earth, &c.

In effect, in ſome bodies, particularly thoſe of the metalline kind, the calcining fire does not operate as in others, particularly vegetables; ſince ſometimes almoſt the whole weight of a mineral ſhall be found in what they call its *calx*; as we ſee in tin calcined *per ſe*: which calx is

Salt, water, oil, and earth, when pure, ſeem to be the ſame in all bodies: and all the difference in ſuch bodies, ariſes from a ſpirit, which reſides in the oil, and is thence denominated the *rector*, or *archæus*. Diſtill, *e. gr.* cinnamon and wormwood as long as you pleaſe; and you will have water, ſpirits and oils, that have the ſeveral taſtes and ſmells of cinnamon, and wormwood: then, burning what remains, you will have ſalts, and earths, in all reſpects alike. But the odorous water abovementioned, in time lays aſide its oil, and becomes inſipid in both; or, if it be expos'd to a gentle fire, the ſpirit all exhales, and leaves it vapid: whence it appears, that the difference lay wholly in the oil. Now, pour ſome of the oil on the water thus effete, and beat 'em ſtoutly together, and you will have the odorous waters of the plants again. Or pour on freſh water, till at length it undergo no alteration, and you will have oils perfectly alike; *i. e.* the oil of cinnamon, and that of wormwood, will be of the ſame kind. Whence, again, it appears, that the *ſpiritus rector* is the cauſe of all the difference. Add, that to whatever this ſpirit is join'd, whether to oil, ſalt, earth, or water, you will in each have all the ſtrength, and virtue of the plant.

*The original difference between the ſame principles of different bodies, lies in a ſpirit.*

Tho' bodies are not reſoluble by chemiſtry into any ſimple, immutable elements; yet they all terminate in a certain number of principles ||.

From *vegetables, e. gr.* are drawn five; *viz.*

1°, *Water*, 2°, *ſpirit*, which is nothing but oil ſo attenuated as to be miſcible with water; 3°, *ſalt*, 4°, *oil*, 5°, *earth*.

From *animals* are drawn a like number of principles; between which, and thoſe of vegetables, there is ſcarce any difference; except, that the ſalt of animals is volatile; and that of vegetables fix'd; and that the latter yield an acid ſalt, which the former do not †.

is in great meaſure reducible ſometimes into a body of the ſame nature with that which afforded it; and ſometimes into another body, far from being elementary: as in the reduction of minium into lead, aſhes of antimony into glaſs, &c. See further in the chapter *earth*, as an *inſtrument*.

|| As vigorouſly as Mr. *Boyle* combats the elements, yet he allows, 1°, That many mineral bodies may be reſolved into a *ſaline*, a *ſulphurous*, and a *mercurial* one; and that almoſt all vegetable and animal concretes, may be reduced, by fire, into five ſubſtances, *ſalt*, *ſpirit*, *oil*, *phlegm*, and *earth*; of which the three former being more operative than the two latter, may be look'd upon as the three active principles, and by way of eminence be call'd the *three* principles of mixt bodies. 2°, That theſe principles, tho' they be not perfectly ſimple, may, without inconvenience, be ſtiled the elements of compound bodies, and bear the names of thoſe ſubſtances which they moſt reſemble, and which are manifeſtly predominant in 'em; becauſe no one of theſe elements ſeems diviſible by the fire into four or five different ſubſtances, like the concrete, whence it was ſeparated. 3°, That ſeveral qualities of a mixt body, and eſpecially the medicinal powers, do, for the moſt part, lodge in one or other of theſe principles. *Scept. Chym.*

† It is remarkable enough, that the order wherein theſe principles ſucceed each other is different, according as the mixt has undergone a fermentation or not: if it have, the ſpirituous liquors, and volatile ſalts riſe firſt, then the aqueous liquors, then fætid oils, leaving a *caput mortuum* at bottom, which affords a fix'd ſalt and earth If it have not fermented, the aqueous liquor precedes the volatile ſalts, and ſpirits; the other matters following in the order abovementioned. *Homberg, Mem. de l'Acad. R. An.* 1702.

As to *foſſils*; ſome of 'em, we have already ſhewn, are reſoluble into two, and others into three principles*.

* That accurate chemiſt, M. *Homberg*, in his new *Eſſais de Chemie*, lays down the principles of foſſil bodies to be ſalt, ſulphur, mercury, water and earth: not that all foſſils contain 'em all; for mercury, he ſhews, is not a common principle: but ſome have it, as metals and metallic minerals; and others not, as ſtones, earths, foſſil ſalts, &c. The principles of all animal and vegetable bodies, according to the ſame author, are ſalt, ſulphur, earth and water. *Mem. de l'Acad. An.* 1702.

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# EFFCTS, or PRODUCTIONS, OF CHEMISTRY.

THE chemiſts, by ſeparating, and uniting, reſolving and compounding bodies, produce an infinite number of effects; all which may be commodiouſly enough reduced to four general claſſes: *viz.* *Magiſteries*, *Extracts*, *Elixirs*, and *Clyſſus's*. *Four effects or productions of chemiſtry.*

*Magiſtery* is a name given by the antient chemiſts to the *maſter-piece* of their art; which is *a change of the form of any body, in all its parts, without making any alteration in the quantity thereof.* Or, a magiſtery *is a body reduced into another body, yet all its former ſubſtance retained.* Thus *Paracelſus*: "If you have the matter of gold, and know how to prepare it, ſo as in "one moment to render all that gold a potable liquid; it is a magiſtery of "that thing. Or if you can convert mercury, or ſilver, or gold, into its "*ens primum*, or radical liquid;" that is, if you can penetrate its whole, intimate ſubſtance, and render it potable, by the admixture of a *menſtruum*, which ſhall reſolve whatever was coherent in the body, "it is a magiſtery." Conſequently, magiſteries require the alcaheſt, or univerſal diſſolvent. *Magiſtery, the proper notion thereof.*

But the apothecaries, and leſs knowing among the chemiſts, apply magiſtery to any conſiderable change of a body into another form; particularly to certain powders diſſolved by menſtruums, and precipitated. Thus if you take an ounce of pearls, and diſſolve it in one or two ounces of ſpirit of vinegar, and then caſt in ſalt of tartar to precipitate the ſolution; the powder of pearls, before ſuſtained in the vinegar, will be now found at the bottom of the veſſel; which powder is perfectly the ſame with the body or ſubſtance of the pearls: and this powder, when waſh'd, is call'd *magiſtery of pearls*. *Popular notion of a magiſtery.*

A magiſtery is diſtinguiſh'd from an extract, and an elixir, in that, in the latter there is a ſeparation of parts; ſome beingtaken and others left behind.

2°, *Extract*,

*Extracts.* 2°, *Extract* is the pure, and efficacious part of a body, ſeparated from the leſs efficacious parts, by means of ſome liquor, or diſſolvent. Or, an *extract* is a chemical effect, perform'd in a ſingle body, by *ſeparating*, and extracting the homogeneous parts thereof, without *changing* 'em : thus, if you have mercury, and from this mercury ſeparate the corroſive ſulphur ; this ſulphur, thus ſeparated, is call'd the *extract of mercury*.

And hence, all *tinctures* are *extracts*. But it is to be carefully noted, that in extracts, the parts are to be actually ſeparated ; for if they be compounded together, and ſo both changed, it is denominated an *elixir*.

*Elixirs.* 3°, *Elixir*, according to the antient chemiſts, and phyſicians, is an eſſence, or rather magiſtery, of ſeveral bodies join'd together : thus, *e. gr.* if I take aloes, myrrh, and ſaffron, of each an equal quantity ; and by digeſtion reduce thoſe three into one potable form ; it is call'd an *elixir* : if I only took one of thoſe ingredients, *e. gr.* ſaffron, it would be a *magiſtery*.

An elixir, therefore, is a compound magiſtery, *i. e.* a compoſitio nof various bodies, chang'd after the ſame manner as a ſingle body is, in a magiſtery.

Yet ſome authors uſe *elixir* for a ſort of compound extract ; *i. e.* a tincture or eſſence, drawn from ſeveral bodies combined together : as if from worm-wood, ſage, and euphorbium, blended together, a tincture be drawn by means of ſome menſtruum.

*Clyſſus's.* 4°, *Clyſſus :* in this the three former *effects* are united : thus, if you have four or five bodies, and from each of 'em draw a tincture or extract ; and mix theſe together, it is called a *clyſſus*. Take, *e. gr.* aloes, ſaffron, and myrrh, and pour ſpirit of wine upon 'em ; this will draw out the reſinous ſubſtance from the myrrh and aloes, and the ſubtile oil from the ſaffron ; leaving the fæces at the bottom. This, ſome call an *elixir*, but inaccurately ; for an elixir is only a maſs of all the ingredients ; but a *clyſſus* an extract from 'em all.

Others make the *clyſſus* to conſiſt of a number of the efficacious principles, drawn from one and the ſame body, purified, and then recompounded, or mix'd again : as when the ſeveral ſpecies of the ſame thing, ſeparately prepared, are united again ; *e. gr.* ſalt, ſulphur, oil, ſpirit, and mercury, are again brought to coaleſce into one body.

THE

# END and USES OF CHEMISTRY.

WE ſaid in our *definition*, that *chemiſtry* was an *art*; and conſequently it muſt regard ſome certain *end*. End is defined by the ſchools, That which is firſt in the intention, and laſt in the execution; or it is that which excites the mind of the artificer to the uſe of certain means whereby a thing is accompliſhed. All arts have ſuch an end as this; and they are exerciſed merely for the ſake of it. The end of chemiſtry appears from the definition we laid down thereof; wherein that art was ſaid to *change* ſenſible bodies, ſo as to diſcover their ſeveral powers, or virtues, *&c.* But all bodies act according to what they are, and not according to what they were, or ſhall be: Conſequently, ſince chemiſtry renders the preſent effects of all bodies, ſenſible, we cannot be at a loſs to diſcover its end; tho' that may be various, according to the views of the operator, or its exceeding uſefulneſs in all the parts of natural philoſophy; as might be made fully appear by a long train of particular inſtances. *End and uſes of chemiſtry various;*

Various are the uſes of chemiſtry; and there is no art whereto it may not be ſubſervient, and aſſiſting. 'Tis very difficult, therefore, to aſcertain all its particular uſes; becauſe, being the largeſt branch of phyſics, 'tis concern'd with all manner of natural bodies, more particularly with fire, the moſt univerſal of them all. *And general.*

*Uſes*

## *Uses of Chemistry in Natural Philosophy.*

*Natural philosophy, what.*

NAtural philosophy, that is, the history of the existence, phænomena, and operations of natural bodies, consists of two parts; the one *experimental*, which nakedly proposes the phænomena of bodies; the other, *argumentative*, which, from the phænomena observ'd, draws new conclusions, by reasoning upon them with geometrical exactness. And as there is no way to discover the actions of bodies, but by experiments; chemistry, which deals entirely with these, must needs be exceedingly useful in natural philosophy. 'Tis by chemical experiments that we learn the actions of one body upon another; and the effects produced by those actions; that is, in other words, the powers and laws of nature.

*Taught by chemistry.*

All the natural bodies existing, may either be in action, or not in action; for, from the passive principle, as 'tis called, or force of inactivity in them, they are indifferent to motion or rest: and we can never know, otherwise than by experiment, which of these two states a body is in. Bodies act not by their corporeal nature; but by a certain further property superadded to them, when created, which determines them to action *. But the principles of their action are either common to them all, or peculiar to some of them. By the former, we can never fully explain the various changes and phænomena of bodies. Who is there, that from the extension and solidity of the load-stone, could say, it must necessarily attract iron? We are, therefore, as natural philosophers, to discover the particular powers inherent in particular bodies; which can never be done without a sollicitous and experimental scrutiny into their nature and actions.

There are two ways, according to the great Lord *Verulam*, whereby natural things become known to us; that is, we may designedly search after them by experiments; or they may casually offer themselves to us without inquiry. Chemistry must necessarily be exceeding fruitful in both; since all the productions of the three kingdoms are, as we have already shewn, its subjects. The latter of these two ways is, in reality, chemistry itself; and, accordingly, all the philosophical experiments made with any view or design, have been derived from that art. Hence, wee plainly see,

* Body being absolutely passive, there is a necessity for some active power or principle to put it into motion, and make it produce the phænomena it affords. Body at rest is not only incapable of acting, but even carries an opposition to action: It has a real *power of inactivity*, a *vis inertiæ*, as we call it; which removes it even out of a state of indifferency, and determines it absolutely to remain inactive: So that not only a contrary power or principle, but that even in a higher degree than the former, is necessary to produce action therein.

The active powers which have hitherto fallen under observation, are gravity; whereby bodies tend toward the centre; attraction, whereby the particles of bodies cohere; the causes of elasticity, electricity, magnetism, fermentation, &c. See this point further consider'd in the notes on the chapter *Of Operations*, p. 171, 172, &c.

'tis

'tis the general end of chemiſtry to ſhew the conditions of the bodies which exiſt, obſerve their changes, and remark the effects they produce.

'Tis chemiſtry which ſhews us philoſophy in action, as the Lord *Bacon* juſtly obſerves: All the antient philoſophers were very buſy in explaining nature by words; but chemiſts alone are practical philoſophers. 'Tis they, for inſtance, who underſtand heat, with the nature thereof, ſo as to be able to produce, exhibit, and apply it to numerous purpoſes. Bid a chemiſt convert gold into glaſs; and, by means of a burning concave, or otherwiſe, he preſently does it. Ask him to ſhew you gold in powder; and, by mixing a little antimony with that metal, he will ſoon render it pulverable. Thus, ſpeculative philoſophy is made practical by chemiſtry; which, at the ſame time that it explains things, actually exhibits them to the eye. And this is the philoſophy ſo much recommended by the ſagacious *Verulam*. *And that practically, or experimentally.*

We muſt own, indeed, that no art has been more prejudicial to natural philoſophy than chemiſtry, whilſt it was not confined to obſervations alone, but called in the aſſiſtance of uncertain reaſoning: as, on the other hand, nothing was ever more advantageous to the ſame, than genuine chemiſtry, whilſt it went no farther than experiment. A chemiſt, therefore, ſhould content himſelf with experiments alone; unleſs he can, with mathematical rigour, draw juſt concluſions from the phænomena he obſerves. Hence it appears, that whoever would procure an exact hiſtory of nature, muſt be firſt acquainted with mechanics, which gives us the general properties of matter; and, in the next place, underſtand chemiſtry, which explains the particular qualities whereby bodies act upon one another. Each of theſe is inſufficient without the other: A mere mechanic could never, from general properties, deduce the ſurprizing effects of gun-powder; and a mere chemiſt, who might do this, would make but a wretched philoſopher, if ignorant in mechanics; becauſe, from ſome particular powers, he would ridiculouſly attempt to explain all the motions in nature. *With what caution to be applied.* *Its nature.*

'Tis from chemiſtry that we know, all the actions of bodies proceed not from any plaſtic ſpirits, or ſubſtantial forms; any dæmons, or ſprights, with which the ſuperſtition of ſome enthuſiaſts hath fill'd the world; but principally from the never-ceaſing motion of fire: and that all theſe actions depend upon mechanical principles; as Mr. *Boyle*, from the art we are ſpeaking of, has excellently and amply ſhewn *. *And doctrine.*

* It is by means of chemiſtry, that Sir *Iſaac Newton* has made a great part of his ſurprizing diſcoveries in natural philoſophy; and that curious ſett of queries, which we find at the end of his optics, are almoſt wholly chemical. Indeed, chemiſtry, in its extent, is ſcarce leſs than the whole of natural philoſophy; as might be ſatisfactorily ſhewn by a thorough chemiſt; after the manner wherein our learned author proceeds to ſhew, that almoſt the whole of medicine is chemiſtry.

## *Uſes of Chemiſtry in Medicine.*

*Medicine, what.* MEdicine is that ſmall part of univerſal phyſics, which demonſtrates by what laws the motions in a human body are perform'd; and aims at nothing more than to diſcover the natural ſtate thereof, with the alterations whereto 'tis liable from what it receives, whether as food, phyſic, or poiſon; whereby it is determined either to health or ſickneſs: and, conſequently, this art has the human body for its object; which, conſiſting of the ſame principles with all other bodies, tho' put together after a different manner, 'tis plain, from what we have ſaid of the uſefulneſs of chemiſtry in natural philoſophy, that it muſt be greatly ſerviceable to phyſic alſo. But, to manifeſt this the more fully, we will point out its uſe in the five ſeveral parts whereof the art of medicine conſiſts.

*Uſefulneſs of chemiſtry in all the parts thereof, viz. phyſiology.* 1. *Phyſiology* borrows moſt of its light from chemiſtry. By phyſiology we mean *that part of medicine which explains the nature of the entire animal machine, conſider'd in its natural ſtate*, when its operations are perform'd in greateſt perfection; or in a ſtate of health; which depends upon a juſt balance of the ſolids and fluids. This part of phyſic, therefore, inſtructs us as to the matter of the human body, the coheſion of its parts, whether ſolid or fluid, their conſiſtence, elaſticity, figure, reciprocal actions upon each other, &c.

In the matter of a human body, mechanics can make no great diſcoveries; but chemiſtry will ſhew us, that all the ſolids which go to compoſe it, are either mere earth, or ſome earthy ſubſtance, held together by a certain attractive force, or by a particular oil; for every ſolid part, when urged with fire, leaves nothing but earth and oil behind it. And hence we learn why the veſſels of our bodies are not, as water, ſpirit, oil, or ſalt would be, ſet looſe, and render'd volatile, by the heat they naturally ſuſtain; or the other powers that continually act upon them: namely, becauſe they are compoſed of an earth that is not to be changed by any ſubſtance, or operation in nature.

Again, no-body but a chemiſt could ſay what kind of liquor the blood is, of what parts it conſiſts, and by what principles it acts; for it does not act ſolely as a fluid, flowing along its canals, according to the laws of hydraulics; but, at the ſame time, exerts a force of its own; which chemiſtry explains, by ſhewing it poſſeſſed of certain active principles, as ſalts, ſpirits, oils, &c. wherein it differs from other liquids: and, by knowing the particular nature and quantities of theſe, a chemiſt will nicely underſtand, and advantageouſly diſtinguiſh between the ſigns of health and ſickneſs.

Indeed, nothing but chemiſtry can ſhew how bodies excited by a particular degree of motion or heat, muſt needs cauſe ſuch and ſuch changes, or produce ſuch and ſuch effects. Suppoſe an ox to feed wholly upon graſs, and to drink nothing but water, for the ſpace of ten years; if as much graſs as was eaten by the ox but in one of thoſe years, were burnt, it would

would afford a large quantity of fixed ſalt; yet, if at length the ox himſelf were wholly burnt, not a grain of fixed ſalt would remain in the aſhes. There is, therefore, a certain power in animals, whereby all the ſubſtances they take in, are changed in their nature; tho', without chemiſtry, 'tis impoſſible to know what kind of power that is. But this art, by ſhewing us that the heat which is always preſent in an animal body, can render all oils and ſalts volatile, directly ſolves the problem. And this is the caſe not only in phyſic, but in all the other parts of natural philoſophy; for chemiſtry will teach us what muſt every where happen in the whole, or different parts, of the ſame or different ſubſtances, from different degrees of motion and heat.

2. *Pathology* is inexplicable by any thing but chemiſtry. 'Tis the office of this part of medicine to *unravel and deſcribe the diſtempers incident to the human body, and to aſſign their nature, cauſes, effects and differences.* If *Hippocrates*, therefore, had underſtood chemiſtry, he would have been infinitely a better phyſician than he was. All that he could do in this part of his profeſſion, was only, with diligence and accuracy, to obſerve the phænomena of diſeaſes; which might let him into ſome knowledge of their nature, after he had ſpent much time in this way: but all his care and pains could never once inform him of the ſtate of the ſolids and fluids, from the beginning of the diſtemper to the end of it: He muſt abſolutely be a chemiſt, who would know how theſe are alterable by heat; and here the skill of *Hippocrates* failed him. He knew not, in a burning fever, for inſtance, that the ſalts of the body were diſſolved, and the oils render'd volatile. That great author, therefore, tho' well verſed in the phænomena of diſeaſes, knew but little of their real nature. Pathology.

No phyſician can, with the leaſt ſhew of probability, account for the rarefactions, obſtructions, concretions, &c. in the human body; nor for the corruption of the fluids thereof, without the aſſiſtance of chemiſtry. The very notion of corruption implies a ſeparation or change in the nature of all the ſalts and oils of bodies; for theſe, being now attenuated and exalted, gain a cauſtic quality; the ſalt, which was before mild, and ſomewhat indiſpoſed to volatility, becoming volatile and corroſive; and the oil, which before was gentle, viſcid, and harmleſs, proving violently ſharp, rancid, and volatile. But by comparing the writings of the antient phyſicians with our chemical philoſophy, we ſhall find that none of them ſpoke to the point about putrid diſeaſes. They aſſigned for the cauſe of theſe a bilous matter, and a melancholy humour; words which carry no meaning: but chemiſtry examines the humours putrefied in the body; compares them with the ſame humours, included for the ſame time in proper veſſels, and expoſed to the ſame degree of heat; whence it exhibits the very ſame effects as, in this caſe, are found in the human body. And it is this art alone, that can putrefy humours to any aſſigned degree; and, conſequently, this alone can teach what muſt enſue upon a ſtagnation of the blood in the body, according to the particular parts wherein it happens; and what will be the effects of particular motions of that fluid. Thus, we can now, from chemiſtry, certainly foretel, that a ſtrong circu-

lation will heat the body too much, render it dry, throw off its finer parts, amaſs the groſſer together, render all the ſalts and oils volatile; and hence explain numberleſs the like phænomena, which none but a chemiſt could poſſibly account for. And hence it proceeded, that the antients never knew how a caries of the bones happened, nor how to cure it; but chemiſtry informs us, that the bones become carious from a putrefaction or corruption of their marrow, whereby it is render'd ſo ſharp, as to corrode their ſubſtance: and the ſame art inſtructs us to ſtop the growing miſchief, by the application of a very ſtrong and penetrating lixivium. If it be ſaid, that ſtill the antients underſtood putrid diſtempers; I grant it as to their effects, and viſible appearances; but not at all with regard to their cauſes: and therefore they never diſtinguiſhed between them, nor gave any rational account thereof.

Semeiotics. 3. The *ſemeiotical* part of phyſic, or *the doctrine of ſigns*, is principally concern'd about the pulſe and urine. Now, all the changes in bodies muſt proceed from cauſes: and when any change is obſervable, 'tis called a phænomenon, and muſt needs be the effect of ſome cauſe or other; but the cauſe always lies deeper than the effect; yet is often diſcoverable by means thereof. Whatever leads to the knowledge of this cauſe, we call a ſign; and the art of diſcovering diſtempers by ſuch ſigns, is term'd *ſemeiotics.* Whence it appears, that chemiſtry muſt be exceeding uſeful in this part of medicine alſo. Suppoſe, for inſtance, a chemical phyſician ſhould find his patient hot and inflamed, his urine red, and his pulſe quick and hard; he will from hence immediately know the ſtate of his fluids, and be aware that they tend to a ſtate of putrefaction.

The antients, as particularly *Hippocrates* and *Galen*, would idly ſay, in this caſe, that the perſon was prey'd upon by the innate heat, in conjunction with the veſtal fire; which innate heat, and the radical moiſture of the body being conſumed, the man muſt immediately die.

*Hippocrates* would, indeed, preſently pronounce the ſentence of death upon any one ſick of an unknown diſtemper, wherein all the ſecretions were obſtructed; whilſt the skin appear'd ſqualid, dry, and parched: But a chemiſt will go deeper into the nature of the thing; and ſhew you, that the aqueous and ſpirituous parts of the blood being here wanting, the ſalts, which are now render'd more ſharp and corroſive, are brought, by the law of circulation, to the fine tender veſſels of the *cerebrum* and *cerebellum*, which they either wound and tear, or elſe prevent the ſecretion of the animal and vital ſpirits therein; whence death muſt neceſſarily enſue: which is ſaying ſomething that ſatisfies the mind, and rationally accounts for the thing.

Again, *Hippocrates* tells us, if the urine be of a very red colour, ſmells ill, and appears frothy, the life of the patient is in danger; but 'tis chemiſtry which lets us know, that oil or ſulphur is the cauſe of colours in liquors; that this oil gives a deeper colour, the finer 'tis broke; and that the more 'tis ground, and ſhook together, the more corroſive it grows; which, in the preſent caſe, is the true phyſical cauſe of the effect. We

may,

may, therefore, ſay, tho' *Hippocrates* was, for his time, and the advantage he had, very well acquainted with *ſemeiotics*; yet a perfect knowledge thereof cannot be gain'd without chemiſtry. The *ſemeiotic* part of medicine, likewiſe, informs us of the conſtitution of the patient. Thus he, whoſe urine is always red, ought to ſuſpect a putrefaction of his juices, or a dangerous tendency thereto; as he, who always makes it pale and limpid, may be thence known to be of a weak conſtitution. And when the ſweat, as well as the urine of a perſon, grows fetid, we learn from chemiſtry, that its ſalts are too much attenuated, and the oils too much exalted: nor could we, without the aſſiſtance of this art, underſtand why the chyle ſhould ſometimes turn acid in the ſtomach, or *primæ viæ*, nor perhaps how animal digeſtion is perform'd.

4. *Hygiene*, which is the fourth branch of medicine, inſtructs us in *the way of preſerving health by diet:* and this entirely depends upon chemiſtry; which alone can ſhew when animal, and when vegetable food is proper; to what conſtitutions water, and to what wine is beſt adapted; where bread, and where fleſh is to be uſed; what is the diet requiſite for a man of a ſtudious, ſedentary life; what for a man of an active employ; and what for a child; which habits demand the uſe of alkalies, and which of acids: with many other particulars of like kind. 'Tis true, all theſe things are diſcoverable by experiments, made on the perſons: but danger attends the making of ſuch experiments; whilſt chemiſtry, without running any riſque at all, ſhews us, that the natural heat of our bodies will turn vegetables acid, and putrefy animal ſubſtances. Whence we may learn, that in caſe of an alkaline diſpoſition of the blood and juices, when the urine appears red, ſmells ill, and taſtes alkalious; vegetable acids are the proper diet, and animal food prejudicial. On the contrary, if the humours are acid, as frequently happens in infants convulſed from a coagulation of the milk in their ſtomachs, broths made of the fleſh of animals, eggs, or the like, are excellent; whilſt vegetable acids would prove hurtful. And this can be learnt from nothing but chemiſtry; which alſo inſtructs us to give each kind of food its proper ſauce or menſtruum, to forward its concoction or diſſolution in the ſtomach. Hygiene.

5. As for the *therapeutic*, or laſt part of phyſic, which regards *the cure of diſeaſes*; all the genuine indications of it are fetched from chemiſtry alone. When a patient is ſeized with a burning fever, chemiſtry immediately informs us, that, from the additional heat, the ſalts of the blood become ſharper; and, as the heat increaſes, are render'd alkaline, and the oils more volatile, and exhalable. Whence we infer, that acids ought to be preſcribed, to prevent the putrefaction that is bringing upon the juices: and this indication could be fetched from nothing but chemiſtry. *And* therapeutics.

'Tis very remarkable of the famous Dr. *Sydenham*, a ſtrict follower of *Hippocrates*, that having never read any thing of chemiſtry or anatomy, he was, about the ſixtieth year of his age, ſtruck with conſternation at the horrid devaſtation made by the confluent *ſmall-pox* in *England*; whilſt all the

the remedies he applied, availed nothing towards abating the violence of the diſtemper: ſo that it kill'd as many as it ſeized on. At length, after it had diſpatched thouſands, the Doctor tells us he diſcovered, that as often as he let his patients, in this caſe, drink ſmall-beer acidulated with ſpirit of vitriol, they conſtantly recover'd: hereby furniſhing us with an eminent inſtance of the great uſefulneſs of chemiſtry to a phyſician; which had he but underſtood, the lives of thoſe he before ſuffer'd to die of this diſtemper, might have been happily ſaved. His ignorance of this art drove him to a like diſtreſs in the cure of convulſions in children; whom he ſaw die in great numbers, notwithſtanding his utmoſt efforts to prevent it; till happening to preſcribe them a few drops of ſpirit of hart's-horn in water, many, he thanks God, were by this means ſnatch'd from the jaws of death. And how could the venereal diſeaſe have been cured, had not this art taught us the uſe of mercury? To what purpoſe ſerved all the purges, glyſters, vomits, and other things of that tribe, till this was diſcover'd? By this *Paracelſus* raiſed himſelf a name, and *Carpus* became immenſely rich. But I ſhould never have done, were I to enumerate all the uſeful diſcoveries made in the curative part of medicine by means of chemiſtry; which has put nnmberleſs remedies of great virtue into our hands, that the *Galeniſts* were ſtrangers to. I need not on this occaſion mention Mr. *Boyle*'s *Ens Veneris*, ſo ſerviceable in the rickets; nor the chemical oil of cinnamon, ſo ſuccesſful in all female diſorders, and particularly thoſe of virgins. Nor is the art of chirurgery, which regards only the cure of the ſolids, leſs indebted to chemiſtry; as will be fully ſhewn under the proceſſes in our third part: So that this art evidently appears to be highly neceſſary and uſeful in every branch of phyſic. But I would not have it inferr'd from hence, that the antient phyſicians diſhonour'd their profeſſion by their ignorance hereof; tho', doubtleſs, had they underſtood chemiſtry, they would have practiſed to greater advantage: and thus much themſelves acknowledge in effect. *Galen* declares, that he long, in vain, endeavour'd to find out what it was in roſes which had the power of cooling: Now, if he had ever diſtill'd them, he would have obtain'd their native ſpirit or quinteſſence, which contains all the virtues of the flower, has the faculty of cooling, and makes the roſe to be what it is. *Hippocrates*, tis certain, perform'd many excellent cures without the aſſiſtance of chemiſtry; but then he acquired his skill by many repeated experiments, which ſhew'd him what was ſerviceable, and what prejudicial in every diſeaſe; and this could not be done without much hazard to the patient. As we are acquainted with a great variety of things unknown to the antients, the arguments drawn from their phyſic, without the late aſſiſtances, and particularly that of chemiſtry, are not to be relied on. We muſt own however, that phyſic has been a conſiderable ſufferer by chemiſtry, from the licentious way of reaſoning introduced into it; and the fondneſs of chemiſts in extolling every production of the furnace for a medicine: yet the faculty at *Paris* carried their reſentment too high, when they woud have utterly expelled it their art; for when uſed under due limi-

limitation, nothing can be more conducive to the advancement of phyſic, than chemiſtry. And for fuller proof of this momentous aſſertion, I refer myſelf to the works of thoſe two unexceptionable authors, the great Lord *Bacon* and the excellent Mr. *Boyle*; after whom there is ſcarce any author, in this way, deſerving to be mention'd, at leaſt, in compariſon of them; their ſucceſſors having done little more than repeat their experiments, or barely tranſcribe their works. The beſt phyſicians ſince their times, have been ſhamefully ignorant in chemiſtry; and the beſt chemiſts as generally unskill'd in medicine *.

* The general ignorance of the antient phyſicians in the chemical part of their profeſſion, led ſome of their modern admirers into a firm perſuaſion, that chemiſtry was of no ſignificance therein: as if, becauſe neither *Hippocrates*, nor *Galen*, ever ſaw a diſtill'd water, all ſuch waters muſt be a trifle. The firſt application of chemiſtry to the purpoſes of medicine, we have already traced out in the hiſtories of *Baſil Valentine*, *Paracelſus*, and *Helmont*.

In the days of *Helmont*, this kind of knowledge had gain'd conſiderable ground; and two men of eminence, Sir *Theodore Mayern*, and *Quercetan*, profeſs'd it publickly at *Paris*; tho' they were ſtrenuouſly oppoſed therein by the faculty, who commiſſion'd one of their members to write an apology for *Hippocrates* and *Galen*, againſt the innovators: But theſe ſtill proving obſtinate, were in the year 1603, publickly cenſured, condemned, and ejected, together with their writings, and their art, by the conſent of the whole college. This raſh proceedure only the more excited the chemiſts to write and divulge their experiments, and made their doctrine more inquired after: upon which, the phyſicians of *Europe* divided into ſects under the name of *Galeniſts* and *Chemiſts*. Many a learned pen was now drawn in defence of the antients; and many an one to recommend the new-found art. In the mean time, freſh diſcoveries in chemiſtry were daily made, and the number of its admirers increaſed; ſo that the *Galeniſts* themſelves were at length prevailed upon ſecretly to try the effects of chemical medicines: which gave them to ſee, that chemiſtry was not, as they imagined, to be raſhly condemned by the lump. And this at length ended in a friendly union of the two pharmacies, *Galenical* and *Chemical*; which muſt be allow'd one of the greateſt and happieſt acceſſions the art of medicine ever receiv'd. The *methodus præſcribendi* entirely depends upon a knowledge of chemiſtry; and to the want of this are owing thoſe groſs errors ſo frequently committed by diſpenſatory-writers, in ordering the ſtanding medicines of the ſhops.

OF

## *Uses of Chemiſtry in the Mechanical Arts.*

THE third uſe of chemiſtry is *mechanical*, or, *in the mechanical arts*; to diſtinguiſh it from that other branch of mechanics, the doctrine of motion; which belongs to mathematics.

*Mechanics, what.* *Mechanics*, as here conſidered, is the art of changing ſenſible bodies, for human uſes, without the exactneſs, and preciſion of geometrical rules, and demonſtrations: in which ſenſe, a work, or effect of ſuch art, is call'd a piece of *mechaniſm* *.

Now the prime uſe of chemiſtry is in ſuch arts: none of which but has received great improvements, and is ſtill in a way of receiving many more, from this noble art; which on this very account has ever been held in the higheſt eſteem by princes, and great men, who had the intereſt of trades, arts, and manufactures at heart. We ſhall ſpecify its uſes in ſome of the more conſiderable: and,

*Uſefulneſs of chemiſtry in the art of painting.* 1°, *In the art of painting*; an art which forms figures, by the draught of lines and colours, and touches ſurfaces till they reſemble natural bodies. Now there is nothing painting ſtands in ſo much need of, as chemiſtry: the great point a painter is ſollicitous about, is to have good colours, that is, ſuch as ſhall retain their luſtre, force, hue, homogeneity, and tranſparency; and 'tis by chemiſtry alone that ſuch colours are prepared: witneſs *ultra marine* †, *cinnabar* ||, *vermillion* **, *lacca* ††, &c. And particularly the firſt, which is a noble vivid blue, and the only durable colour of the kind; all other

* "The antients," ſays Sir *Iſ. Newton*, "made two kinds of mechanics: *rational*, "which proceeds by demonſtration; and "*practical*, to which belong the manual "arts, whence the name mechanics was "originally taken. But in regard artificers uſually work inaccurately, by this "means mechanics have come to be diſtinguiſhed from geometry; ſo that "whatever is accurately done, is referr'd "to geometry, and the reſt, leſs accurately perform'd, to mechanics. Yet does "not the difference lie in the thing, but "wholly in the men. He that works inaccurately, is an imperfect mechanic; "and he muſt be allowed the beſt of all "mechanics, who works the moſt accurately of all. In effect, mechanics, or the "mechanic arts, are, as it were, the baſis of geometry; the drawing of right "lines and circles, which geometry is to "conſider, being wholly mechanical." *Præf. ad Phil. Nat. Princ. Math.*

† *Ultra marine.* The method of preparin it, we have already given in the notes, *p.* 137.

|| *Cinnabar.* See what we have already obſerved hereof, in the notes, *p.* 132.

** *Vermillion*, the antient minium, is prepared of native cinnabar, by grinding it up with ſpirit of wine, and urine, and then drying it.

†† *Lacca*, or *lake*, is a fine red, of three kinds, *viz. Venetian*, *dove-colour'd*, and *liquid*: the firſt is made of the bone of the cuttle-fiſh pulverized, and colour'd with a tincture of cochineel, and *Braſil* wood, boil'd in a lixivium of burnt alum, arſenic, natrum, or the ſalt of kali, reduced into a paſte, and form'd into tablets or cakes. The ſecond is made of ſhreds, flox, or ſheerings of ſcarlet, boiled in the ſame lye as the former, ſtrained, and caſt upon powder'd chalk, and alum, to be form'd into tablets. The third is only a tincture of the wood call'd *Fernamboug*, drawn by acid juices. *Savary.* There

other blues, and consequently the greens depending thereon, fading, and losing all their beauty in course of time. The chemical process for making it, is somewhat long: *See Anth. Neri, de producto azyron.* Add, that it is chemistry which teaches how to mix and *compound* colours; what *vapours* spoil and deface 'em; and what means, as *varnishes*, &c. are to be used to preserve 'em.

As to the other branch of *painting*, viz. *on glass*, whereby colours are laid on that body without destroying its transparency; tho' it be of an antient standing, yet was almost lost, and only at length restored by means of chemistry. *Kunckel* was the first who retrieved this noble art; who, tho' he speaks of it in terms scarce intelligible; yet was undoubtedly well seen therein *. *Painting on glass.*

A

There are also yellow lakes, orange lakes, &c. procured, in the like way of tinctures, from broom-flowers, poppies, flower-de-luces, roses, violets, mallows, &c. *Anth. Neri, de re vitrar.*

* The *colours* used in staining or painting on glass, are all of the metalline, or mineral kind, and not procured without chemical operations, and many of 'em painful ones too: *Black*, according to *Felibien*, is made of scales of iron, ground with glass beads: *White*, with sand, calcined, pounded, mixed with salt-petre, and the mixture recalcined, repulveriz'd, &c. *Yellow* is leaf-silver, ground, and mix'd in a crucible, with sulphur or salt-petre; ground a second time and mix'd with oker. *Red* is made of litharge of silver, and scales of iron, gum arabic, glass-beads, blood-stone, &c. *Green*, of *æs ustum*, black lead and sand calcined, and incorporated; then salt-petre added; then calcined a second time, and a third time yet e'er it be used. *Blue, purple and violet*, are prepared like green, only leaving out the *æs ustum*, and in lieu thereof using sulphur, for sky blue; perigueux for purple; and both for violet. We must add, however, that these colours are not universal; most painters on glass having their particular ones, which they keep secrets.

*Method of staining or painting on glass.*

*To paint on glass*, they first design their subject on paper; then make choice of pieces of glass, proper to receive the several parts; and thus proceed to distribute the design on the paper it self into pieces suitable to those of the glass: contriving, that the glasses may join in the outlines of the figures, and the folds of the draperies; that so the carnations, and other finer parts may not be damaged by the lead, in joining the pieces together.

The distribution made, they mark all the glasses, as well as the papers, with letters, or numbers, that they may be known again. Which done, applying each part of the design on the glass intended for it, they copy, or transfer the same upon the glass, with the black colour diluted in gum-water, by tracing and following all the lines and strokes as they appear thro' the glass, with the point of a pencil.

When the first strokes are well dried, which happens in about two days, if the work be only in black and white, they give it a slight wash over with urine, gum-arabic, and a little black; and this several times repeated, according as the shades are desired to be heightened: with this circumstance, never to apply a new lay till the former is sufficiently dried. This done, the lights and risings are given by rubbing off the colour in those places with a wooden point, or the handle of the pencil.

As to the other colours above mentioned, they are used with gum-water, much as in painting in miniature; taking care to apply them lightly, for fear of effacing the out-lines of the design; or even for the greater security, to apply them on the other side: especially the yellow, which is very pernicious to the other colours, by blending therewith.

*Enamelling.* A third manner of painting, call'd *enamelling*, or the art of laying the fineſt colours on metals, and precious ſtones, ſtands wholly on the footing of chemiſtry: nor can any thing be written on the ſubject but what is fetch'd from that art †. See *Iſaacus Hollandus on enamelling*.

2°, *In*

And here too, as in pieces of black and white, particular regard muſt be had, not to lay colour upon colour, or lay on lay, till ſuch time as the former are well dried. It may be added, that yellow is the only colour that penetrates the glaſs, and incorporates therewith by the fire: the reſt, and particularly the blue, which is very difficult to uſe, remaining on the ſurface, or at leaſt entering very little.

When the painting of all the pieces is finiſh'd, they are carried to the furnace to anneal, or bake, and fix the colours thereon. This furnace is ſmall, and built of brick; a little above the bottom is an aperture to put in fuel, over which is a grate, which traverſes the furnace, and divides it into two parts; above this is an aperture, thro' which to take out pieces, and examine how the coction goes forward.

On the grate is a ſquare earthen pan, on one ſide whereof, is a little aperture, thro' which to make the trials, placed directly oppoſite to that in the furnace deſtined for the ſame end.

In this pan are the pieces of glaſs placed in the following manner: firſt, the bottom is covered with three ſtrata of plaiſter, or beaten lime, ſeparated from each other, by two others, of broken glaſs; ſerving to ſecure the painted glaſs from the too intenſe heat of the fire. The glaſſes are laid horizontally on the uppermoſt layer of this plaiſter or lime.

This firſt row of glaſſes they cover with a lay of the ſame powder, an inch deep; and over this lay another range of glaſſes: and thus alternately till the pan is quite full.

The pan thus prepared, they cover up the furnace with tiles, or a ſquare table of earth cloſely luted all round; only leaving five little apertures, one at each corner, and another in the middle, to ſerve as chimneys.

Things thus diſpoſed, there remains nothing but to give fire to the work: the fire for the two firſt hours muſt be very moderate, to be increaſed in proportion as the coction advances, for the ſpace of ten or twelve hours, in which time it is uſually compleated. At laſt, the fire, which at firſt was only of charcoal, is made of dry wood; ſo that the flame covers the whole pan, and even iſſues out at the chimneys.

During the laſt hours, they make eſſays from time to time, by taking out pieces thro' the little aperture of the furnace, to ſee whether the yellow be perfect, and the other colours in good order. When the annealing is thought ſufficient, they proceed haſtily to extinguiſh the fire, which otherwiſe would ſoon burn the colours, and break the glaſſes.

† The *enamels* or colours uſed in this art, have for their baſis a pure cryſtal glaſs or frit, ground up with a fine calx of lead and tin prepared for the purpoſe; with the addition, uſually, of white ſalt of tartar. Theſe ingredients baked together, are the matter of all enamels; which are made by adding colours of this, or that kind, in powder, to this matter, and melting or incorporating 'em together in a furnace: when melted, they are caſt into water; and when dry, melted over again, and the colour rais'd, or taken down at diſcretion. For *white enamel*, *Neri* directs only manganeſe to be added to the matter. For *azure*, zaffer mix'd with calx of braſs. For *green*, calx of braſs, with ſcales of iron, or with *crocus martis*. For *black*, zaffer, with manganeſe, or with *crocus martis*; or manganeſe with tartar. For *red*, manganeſe, or calx of copper and red tartar. For *purple*, manganeſe with calx of braſs. For *yellow*, tartar and manganeſe. *De Arte vitrar.*

Enamelling, to appear in perfection, ſhould only be practiſed on plates of gold; the other metals being leſs pure: copper, for inſtance, ſcales with the application, and yields fumes; and ſilver turns the yellows white. Nor muſt the plate be

made

2°, *In the art of dying*, by which we mean that noble invention of tinging wools, silks, linnens, *&c.* with the brightest colours. For most of the best colours are owing to chemistry, particularly *blue*, *i. e.* indigo **; and *red*, *i. e.* scarlet; which last was first introduced by *Kuffelaer*, a dyer of *Lions*, who married *Drebel's* daughter, from whom he had a *M S.* of the father, about *dying a flame colour*, which furnished him with the first hint. *Dying.*

For *Drebel* finding, by chemical experiments, that cochineel with spirit of nitre ||, afforded such a colour; and finding withal, by further experiment, that the pure spirit of nitre corroded cloth, he temper'd it with tin. And hence arose that celebrated colour, which neither fire, nor water, nor salt can destroy.

Besides,

made flat; for in such case the enamel crackles: to avoid which, they usually forge 'em either a little round, or oval; and not too thick.

The plate being well and evenly forg'd, they usually begin the operation by laying on a couch of white enamel, on both sides, which prevents the metal from swelling or blistering: and this first lay, serves for the ground of all the other colours.

On the plate, thus enamell'd with white, they calk or trace the design to be painted; touching and finishing it up with some other colour. This done, the plate is set in a reverberatory furnace, to fix the colour; and the other colours applied in like manner in their turns. The white colour of the ground serves for the lights, and is therefore spared in all the places where such heightnings are required. *Felibien, Prin. de l'Architect. de la Sculpt.* &c.

** *Indigo* is a fecula procured from the leaves of a shrub of the same name; frequent both in the *East* and *West Indies*; where they plant and cultivate it with great care. When ripe, *i. e.* when the leaves are brittle, and break by only touching, which happens in two months after the are planted, they cut 'em, tye 'em up in bundles, and lay 'em to rot in large vats of river, or spring water. In three or four days, the water boils and ferments by mere force of the plant heating it, *&c.* Upon this they stir it up with large poles; and then letting it stand to settle again, take out the wood, which is now void both of leaves and bark. Lastly, continuing to stir what remains at bottom divers times, after it has settled for good, they let out the water, take the sediment which remains at bottom, put it in forms, or moulds, and expose it in the air to dry: and this is indigo. This is the most usual way of preparing it. Others practise it with some variety.

|| Authors are divided, as to the nature of *cochineel*; some taking it for a worm, and others for the grain or seed of a tree. *F. Plumier*, the Minime, maintains the former opinion, and *Pomet* the latter.

It may perhaps be said they are both in the right, and yet both in the wrong; and that there is *cochineel* of either kind. This at least, appears from the account given by *Dampier*; who describes each kind.

" The *cochineel worm*, he says, is an in-" sect gender'd in a fruit resembling a " pear: the shrub which bears it, is five " or six foot high, and call'd *tonna*, of " which they have whole plantations a-" bout *Guatimala*, *Chepe*, and *Guexaca*. A-" top of the fruit grows a red flower, " which when mature, falls on the fruit; " and that opening, discovers a clift two " or three inches diameter. The fruit " then appears full of litttle red insects, " having wings of a surprizing smallness, " and which would die and rot there, if " not taken out. The *Indians* therefore " spreading a cloth under the tree, shake it " with poles, till the insects are forc'd to " quit their lodging, and fly about the " tree, which they cannot do many mo-" ments, but tumble down dead into the " cloth; where they are left till en-" tirely dry. When the insect flies, it is red; " when fallen, it is black; and when dry, " white; it afterwards changes colour.

" *Cochineel grain*," or, as *Dampier* calls it, *sylvestris*, " is a red berry, growing in " *America*, found in a fruit resembling that " of the cochineel tree, or tonna. The

 " first

Besides, no colours will stick to wool, or silk, unless there have first been a fermentation, which is purely chemical. If then I would dye silk, *e. gr.* scarlet, there are two things required: 1°, a proper colour; and 2°, that the colour stick to the silk; both of which depend on chemistry. For as to the first, if the silk be first boil'd in a lixivium, the colour readily adheres: And as to the second, that colour cannot be prepared without *Aqua fortis*, or spirit of nitre; and that again, as already observed, is to be temper'd with tin: And thus all the durable metallic colours are only to be had by this art. Nor can a dyer use 'em to their utmost advantage, without the assistance thereof.

*Art of glass.* 3°, *In the art of glass*; an art, how noble, how necessary, and how advantageous to mankind! by which alone we let in light, and warmth, and keep out the air, filth, *&c.*

Its first rise * it had in *Egypt*, and its perfection in *England*: But both are apparently owing to chemistry.

It is made of sand calcined, or of flints often ignited, and as often suddenly extinguished in water, to render them friable, and then pulverized, and mix'd with an equal quantity of vegetable ashes, for the sake of the fix'd al-

" first shoots produce a yellow flower; " then comes the fruit, which is long, " and when ripe, opens with a clift of " three or four inches. The fruit is full " of kernels or grains, which fall, on the " least agitation, and which the *Indians* " take care to gather. Eight or ten of " these fruits may yield about an ounce " of grain.

" This berry yields a dye almost as " beautiful as that of the insect; and a " person may be easily deceived in them; " tho' the first is much less esteem'd."

* *Neri* traces the antiquity of glass as far back as the time of *Job*: That writer, speaking of the value of wisdom, c. 28. v. 17. says, that gold and glass are not to be equal'd to it: so, at least, our version has it, after the *Septuagint*, *Vulgate*, the *Syriac*, St. *Jerom*, &c. But in other translations, as well as in the original *Hebrew*, the word glass is not seen: instead thereof, the *Chaldee* uses crystal; the *Arabic*, jacinth; the *Italian*, *Spanish*, *French*, *Dutch*, a diamond; the *Thargum*, a looking-glass; *Pagninus*, a precious stone; *Vatable*, a beryl, *&c.* The reason of all this diversity arises hence, that the original word *Zechuchich* comes from the root *Zacac*, which signifies to purify, cleanse, shine, be white, or transparent; whence the same word is applied to frankincense, *Exod.* 30. 34. where the *Septuagint* renders it pellucid: so that the word may equally signify any thing beautiful, and transparent; and is by no means peculiarly appropriated to express what we now call glass. *Merret. Observ. in Anth. Neri.*

*Pliny* relates, that " glass was first dis- " covered by accident in *Syria*, at the " mouth of the river *Belus*, by certain " merchants driven thither by the for- " tune of the sea, and obliged to conti- " tinue there, and dress their victuals by " making a fire on the ground; where " there being great store of the herb *kali*, " that plant burning to ashes, its salts " mixed and incorporated with sand or " stones fit to vitrify or make glass." *Hist. Nat. lib.* 36.

Dr. *Merret* will have glass as antient as either pottery, or making bricks; for that a kiln of bricks can scarce be burnt, or a batch of pottery be made, but some of the bricks, and the ware, will be at least superficially turn'd to glass: so that it must have been known at the building of *Babel*, and as long before as that art was used; and likewise by the *Egyptians*, among whom the *Israelites* were many years employ'd in making bricks. *Observ. in Anth. Neri.* Of this kind, no doubt, was that fossil glass mentioned by *Ferrant. Imperat.* to be found under ground in places where great fires had been. *Lib.* 25. *c.* 7.

caline

caline ſalt therein: the whole they heat, and boil, till it becomes glaſs *.

If the ſand or ſtone be in too great quantity, or be not beat ſmall e-nough, the glaſs is greeniſh; but the more ſalt, and the finer the calx, the more clear and beautiful the glaſs.

In effect, glaſs is only an alkali ſalt, united with a calx or earth; and the more fixed the ſalt, and the purer the earth, the finer the glaſs: but then the more ſalt, and the finer the glaſs, the leſs it endures the air; as being ſubject to veins and cracks, and being eaſily prey'd on, and diſſolved by the water in the air.

And the more the earth, the greener and more opake the glaſs; but withal the more durable. Add, that the finer the glaſs, the more it changes bodies put therein.

4°, *In the art of gems*, by which we mean the art of making precious ſtones or gems, of cryſtal or glaſs, to vye in beauty, colour, hardneſs, &c. with natural ones. *Art of gems.*

To the perfection of this art, two things are required: Firſt, the giving the glaſs or cryſtal an exceeding hardneſs, ſolidity, and tranſpa-rency. And, 2°, the giving them a bright and tranſparent colour or water. *What it turns on.*

Now, the two ſorts of matter juſt mentioned, *cryſtal* and *glaſs*, have each their particular advantages, and defects; by which they are diſ-poſed, and indiſpoſed to come up to the quality of gems: *Cryſtal*, for in-ſtance, has a noble hardneſs, compactneſs, and pellucidity; but then it does not take colour: at leaſt the art of tinging or ſtaining it, is not now known. The chemiſts of the laſt age, 'tis true, ſeem to have underſtood it better: *Kunckel* particularly had a method of dying cryſtal of a beautiful red, by means of a little gold; but the ſecret periſh'd with him †. *Glaſs and cry-ſtal; the matter thereof.* *What is want-ing in cryſtal.*

Mr. *Boyle*, in his excellent treatiſe of *gems*, has endeavour'd to retrieve this art, and to ſhew how a cryſtal matter may be converted into a real gem; but he never brought the thing to bear himſelf. All his cryſtals crack'd, and flaw'd; which flaws, &c. the air entering, corrupted and diſſolved them: ſo that in a little time they loſt all their tranſparency.

As to *glaſs*, it receives any colour, and that in all imaginable perfection; but then it wants both of weight, compactneſs, and hardneſs; witneſs its being cut by a cryſtal, as by a diamond: But, which is more, it is de-fective too in the point of ſmoothneſs, and poliſh: for if its ſurface be a little rubbed, or ground, it appears rough and unequal, and loſes all its tranſ-parency and beauty; whereas rock-cryſtal takes the nobleſt poliſh. How-ever, in point of colour, glaſs excels every thing. *What in glaſs.*

* The nature and ingredients of glaſs, with the proceſs of making it, &c. we have already deſcribed in the notes, *p.* 139, 140.

† Tho' *cryſtal*, in not being fuſible, be-comes unſuſceptible of dyes, or tinctures in ſubſtance; yet the induſtry of the chemiſts has found means of making it ſerve for the baſis of precious ſtones, with all the advantages of colour. Tho' we cannot fuſe, we can calcine, and make frit of it.

To

To make, *e.gr.* a fine, vivid, durable blue; take pure ſalt, and ſea-ſand: boil theſe a long time in an intenſe fire, then mix a tincture of copper; and continue the heat till all three be fuſed, and vitrified: the reſult will be a gem, or emerald, nothing inferior in beauty to a native one; and ſuch, as we have known the moſt experienced lapidaries deceived in ‖. We

‖ The *art of imitating precious ſtones in glaſs*, is too curious and conſiderable to be paſs'd over without further notice; ſome of the leading compoſitions therein, we ſhall briefly point out, on the authority of the never-enough to be commended *Neri.*

*To make a ſea-green glaſs*; Take cryſtal frit, without allowing it any manganeſe; melt it, and when clear, a ſalt will be found ſwimming a-top, in form of an oil, which is to be skim'd off, as long as any riſes. When the glaſs is perfectly clarified, mix calcined braſs, and zaffer; and add the mixture to the melted cryſtal. Let the whole ſtand three hours, that the colour may incorporate with the metal: then ſtir and mix them again; take a proof, and either heighten or take down the colour.—— *For an emerald-colour glaſs*, uſe cryſtalline metal that has had no manganeſe, paſs it thro' water once or twice, to get out all the ſalt; add half the quantity of common white metal made of polverine; and when the mixture is well purified, add braſs thrice calcined, and *crocus martis* calcined with brimſtone, and reverberated: If any blueneſs remain, add more of the *crocus.*——*For a turcois-colour glaſs*, evaporate all the moiſture from a ſea-ſalt, till it become white; then pulverize it: this powder add, by degrees, to a ſea-green cryſtal metal, mentioned above, mixing it well together, till the ſea-green loſe its tranſparency, and become opake, which is the effect of the ſalt, now vitrified. Upon this, a little paleneſs ariſes, and by degrees the sky-blue, which is the colour of a turcois-ſtone. ——*To make calcidony's, jaſpers, and agats*, in glaſs; diſſolve ſilver in *Aqua fortis*, and alſo mercury in *Aqua fortis*; mix the ſolutions in a glaſs body, and to the mixture add ſal-ammoniac; when diſſolved, add zaffer, manganeſe, ferretto, *crocus martis*, thrice calcined copper, blue ſmalt, and red lead, all in powder; keep the body ſtopp'd ten days, ſtirring it daily: then put it in a ſand-furnace; in twenty-four hours the *Aqua fortis* will be evaporated, leaving a powder at bottom. Laſtly, take very clear metal, made of broken pieces of cryſtal, and cryſtalline veſſels, and white glaſs that has been uſed: to twenty pound of this, add two ounces and a half of the powder; mix, and incorporate them, and let them ſtand in the fire twenty-four hours; upon this, when grown cold, waves and clouds of beautiful colours will begin to appear. Add, tartar, vitrified ſoot, and *crocus martis*, calcined with brimſtone, all powder'd and mix'd, to the compoſition: let it boil, and ſettle twenty-four hours; and then make a glaſs body of it, which put in the furnace again and again, till there appear fine ſtreaks, and ſhades of blue, red, ſea-green, yellow, and all other colours; in which ſtate it is ready to be wrought into variegated veſſels, &c.

*To make a gold-yellow in glaſs*, mix cryſtal frit with common glaſs frit, and to the mixture add tartar beaten and ſearced, and manganeſe; place them in a furnace four days, with an ordinary fire; when ſufficiently purified, and colour'd, work it.——*For a granat colour*, to cryſtal, and common frit mix'd, add manganeſe, and zaffer; put them in a pot, and keep them in the furnace twenty-four hours.——*For an amethyſt colour*, to cryſtal frit add manganeſe and zaffer, as before.——*For a ſaphyr colour*, either to common or cryſtal frit, add zaffer and manganeſe; mix and melt them in the furnace, and, when well-colour'd, work it.——*For a black colour*, to cryſtal and common frit, add calx of lead and tin; mix, and ſet them in the furnace: when the metal is melted, and pure, add powder of calcined ſteel, ſcales of iron; after boiling with the mixture, let them ſtand and ſettle twelve hours.—— *For a ſnow-white*, to cryſtal frit add calcined tin, and manganeſe; mix them, and ſet them in the furnace to refine, for eighteen hours: then caſt the matter into water, and make a proof: if it be too clear, add more of the tin.——*For a marble colour*,

We have lately ſeen an eminent artiſt at *Amſterdam*, the ſame who firſt ſet on foot the method of making *porcelain* of glaſs; and were ſhewn by him glaſſes of all imaginable colours *. He has the art of imitating to the life any human eye †, and all upon a ſingle piece of convex glaſs; not by painting it, but only applying glaſs to glaſs. He aſſured us, he learnt all his art from *de Neri*, and *Kunckel* in his comments on the ſame; which laſt author made a ſort of precious glaſſes in the court of *Pruſſia*, equal to any precious ſtones; ſome of a ruby colour, with gold; others of a ſmaragd colour, with copper, *&c.* See *Joh. Kunckelii Vollſommene Glaſmacherkunſt*, d. 1. *Ant. Neri 7. Bucher de Arte Vitraria.*

5°, *In*

*colour*, cryſtal frit melted, and work'd without purifying, ſuffices.—— *For a deep red*, put cryſtal frit, broken white glaſs, and calcined tin, in a pot to melt, and purify; and when in fuſion, add calcined ſteel, and ſcales of iron, well powder'd, thereto; mix, and let them incorporate five or ſix hours. Make an eſſay, and if the metal be too black or opake, add braſs calcined to a redneſs; mix, refine, and make eſſay as before, till it be of a blood-red; and work it ſpeedily, leſt it loſe its colour.

* It is no inconſiderable improvement of the art of imitating gems in glaſs, to make uſe of glaſs of lead; the ſtones produced hereby, far exceeding thoſe made of common glaſs, or even of cryſtal, in point of colour. To prepare this glaſs, the lead is firſt fuſed and calcined in a kiln; then re-calcined by a reverberatory fire; and laſtly, polverine or rochetta frit being mixed therewith, and the whole ſet in the furnace for ten hours, it is caſt out into water, and the glaſs ſeparated from the lead.

This glaſs may be blown or work'd into veſſels, after the uſual manner.——It becomes of an *emerald colour*, by the addition of polverine frit to purify it, and braſs thrice calcined, and *crocus martis* made with vinegar, incorporated therewith.—*A topaz-colour*, by uſing cryſtal frit inſtead of polverine frit, and adding half the quantity of yellow glaſs.——*A granate colour*, by adding cryſtal frit, manganeſe, and zaffer.——*A gold-colour*, by adding cryſtal frit, braſs thrice calcined, and *crocus martis*.—— *Colour of lapis lazuli*, by adding the ſnow-white glaſs above-mentioned, with the painters blue ſmalt. *Neri ubi ſupra.*

† M. *Homberg* gives us a new and curious application of the art of glaſs to the copying of *engraven ſtones*, and taking figures or impreſſions thereof, equally beautiful with the originals. He even aſſures us, that he made copies this way from a great number of ſuch ſtones, furniſhed him by the Dutcheſs of *Orleans*, in ſuch perfection, that ſome of the moſt experienced perſons took them for antique.

" The whole method conſiſts in moulding the graven ſtone in a fine earth, and imprinting therein a piece of glaſs half melted by the fire, in ſuch manner, as that the figure of the ſtone remains accurately impreſſed on the glaſs.

The chief difficulty lies in finding an *earth* fine enough to take the figure, and yet that ſhall not melt, mix, ſtick to, and incorporate with the melted glaſs, which itſelf is little elſe but a ſort of earth. The character of ſuch earth muſt be, that it have as little ſalt as poſſible, ſalt diſpoſing more eaſily to fuſion. Of all the earths whereof M. *Homberg* made trial, the leaſt ſaline, and that which he found fitteſt for the purpoſe, was a ſort of chalk, called *tripoli* of *Venice*, commonly uſed in poliſhing looking glaſſes, optic-glaſſes, and precious ſtones: Tho' there is alſo a coarſer *tripoli* found in *France*, of ſome ſtead, in ſaving the too great expence of the former.

The proceſs is thus; pounding the *French tripoli*, paſs it thro' a hair ſieve, ſcrape the *tripoli* of *Venice* very fine with a knife or piece of glaſs; paſs it thro' a fine ſilk ſieve, and pound it in a glaſs mortar, with a peſtle of glaſs.

Proceed now to moiſten the *French tripoli* with water, till it may be made into

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*Art of fossils.* 5°, *In the art of fossils*; it being chemistry alone that shews to find the metalline glebe or ore in the mines; to judge of the value, and richness of earths; to discover whether or no there be any metal in them, and what metal it is; as also how they are to be dug, and the metal procured, and separated from all heterogeneous matters; and lastly, how it is to be cleared of other metals mix'd therewith.

'Tis certain, the *Spaniards* have lost many millions in *America*, for want of the method of separating gold from other matters, by mercury; for gold is there rarely found without being mix'd with other bodies, and this so strongly, as not to be separable by *Aqua fortis*, nor by any other means; till a chemist, invited over into *Peru* on that occasion, first applied mercury, which, uniting the gold to itself, left the rest behind *.

We are told of another, who had the art of separating all the sulphur from tin; which left the metal as fine as silver: but that secret perished with him.

*Art of metals.* 6°, *In the art of metals*, by which we mean the art of refining metals, and rendering them malleable, and fit to be wrought into utensils, and other occasions of life.

Now the malleability of metals, as already noted, depends on their being free of sulphur: Thus, a little arsenic, or other sulphurous matter, being added to gold, it immediately commences friable, and easily crumbles into a fine powder. To purge out all the sulphurous part, therefore, without carrying any of the metalline part along with it; it must be known what bodies attract, and draw the sulphur to them, leaving the metal behind; which is a thing chemistry alone can teach, and by which the *Spaniards* save immense riches in their *American* works, which would otherwise be lost. All the secret

a paste by squeezing it between the fingers; and therewith fill a little flat crucible, pressing it lightly into the same: then strew some dry powder of the *Venice tripoli* over it; and on this lay the stone intended to be moulded; pressing it strongly into the same with the fingers, and flatting down the *tripoli* all around it. Here letting it remain a while, for the moisture of the *French tripoli* to penetrate the *Venetian*; turn the crucible upside down; upon which the stone falls out, leaving its impression behind.

The crucible having now stood till perfectly dry, take a piece of glass of any colour at pleasure, and of a size answerable to the work intended, and expose it in a furnace till it begin to shine, which shews it sufficiently softned for the impression. Upon this, immediately apply it with a piece of iron into the cavity of the mould; and as soon as it has taken the impression, set the crucible in a warm place in a furnace, that the glass may cool by degrees, without cracking: when cold, it is taken out of the crucible, compleat.

To copy a stone *in Creux*, that is, imboss'd, or wrought *in Relievo*; or to copy *in Relievo* a stone wrought *in Creux*, proceed thus:

Take the impression of the stone in *Spanish* wax, or sulphur, and pare off all that is superfluous on the edges; mould this waxen impression, in a crucible of *tripoli*, in the same manner as if it were a stone; and take an impression thereof in a piece of glass, as above taught. *Mem. de l'Acad. An.* 1716.

* See what has been already deliver'd hereof, in *p.* 70 & 74.

con-

consists in casting in an alcali salt, which absorbs the sulphur, and leaves the metal untouch'd.

'Tis chemistry, which alone teaches how to temper metals, and make them ductile, or rigid, or hard, or tender, *&c.* Thus pure gold is scarce of any real use in life, as being so exceedingly soft, and perishable; but fuse it with a little copper, and the colour rises more beautiful, and the metal more firm and durable. The same may be said of pure silver, which is too soft for use; but mix a little tin with it, and it becomes more ductile, and durable.

7°, In the *art of war*, which, as now managed, owes all its force to gun-powder; immediately upon the discovery of which, *guns*, *mortars*, *bombs*, and other furniture of war, were introduced. *Military art.*

In reality, 'tis this powder is the very basis of the modern military art; that, by which sieges, and defences of towns, battles, *&c.* are performed. And hence it was, that *Coehorn*, by being throughly acquainted with the force of gun-powder, bore the palm from all the world, in this way.

Now, gun-powder is a mere chemical production; and, as such, is usually ascribed to * *Bartholdus Schwarts*, a *German* monk; tho', in reality, its *Gun-powder.*

* What evidently shews the ordinary account of its invention false, is, that *Schwarts* is held to have first taught it the *Venetians* in the year 1380; and that they first used it in the war against the *Genoese* in a place antiently call'd *Fossa Caudeana*, now *Chioggia.* For we find mention of fire-arms much earlier: *Peter Messius*, in his *Variæ Lectiones*, relates, that *Alphonsus* XI. King of *Castile*, used mortars against the *Moors*, in a siege in 1348; and *Don Pedro*, bishop of *Leon*, in his chronicle, mentions the same to have been used above four hundred years ago, by the people of *Tunis*, in a sea-fight against the *Moorish* king of *Sevil.* *Du Cange* adds, that there is mention made of this powder in the registers of the chambers of accounts in *France*, as early as the year 1338.

The composition of gun-powder is as follows: Take six pound of salt-petre well purified, and reduced to powder; one of sulphur, likewise, purified, and powder'd; and at least one of charcoal: put these ingredients in a mortar, moisten them with water, spirit of wine, vinegar, or urine, and pound them for twenty-four hours, remembering to moisten from time to time, to prevent the mass from taking fire. This done, squeeze it thro' a sieve. By this means it will be form'd into little grains or globules, which being dried, are the gun-powder. *Wolfii Element. Pyrotech.*

Other authors prescribe other proportions: *Semienowitz*, for mortars directs 100 pounds of salt-petre, 25 of sulphur, and as many of charcoal; for great guns, 100 pounds of salt-petre, 15 of sulphur, and 18 of salt-petre; for muskets and pistols, 100 pound of salt-petre, 8 of sulphur, and 10 of charcoal. *Pyrotech.*

*Miethius* extols the proportion of one pound of salt-petre to three ounces of charcoal, and two, or two and a quarter of sulphur; than which, he affirms, no gun-powder can possibly be stronger. He adds, that the usual practice of making the gun-powder weaker for mortars, than guns, as in the example above, is without any foundation, and renders the expence needlesly much greater: for, whereas to load a large mortar, 24 pound of common powder is required; and, consequently, to load it ten times, 240 pound: he shews, by calculation, that the same effect would be had by 180 pound of the strong powder. *Artiller. Prax. Recent.*

The explosion of gun-powder is thus accounted for by Sir *Isaac Newton*: "The charcoal and sulphur easily ta-"king fire, kindle the nitre, and the "spirit of the nitre being thereby rare-"fied into vapour, rushes out with ve-"hemence, much after the same manner "as

its firſt diſcoverer appears to have been Friar *Bacon*; who 'tis certain was maſter of the ſecret; but out of good will to mankind concealed it *.

The ſame powder, we can make by chemiſtry much more powerful; *viz.* by adding ſalt of tartar to the ſalt-petre, ſulphur and charcoal †.

*Granadoes.*

Miſſive fires or *granadoes* are likewiſe capable of being made to burn; and have their effect inviſibly, or under water, *&c.* Add, that if *Aqua fortis*, or oil of vitriol, be mix'd with the compoſition of a hand granado, every living thing near the place of exploſion will be ſuffocated.

Indeed, 'tis to be lamented, an art ſo fatal and pernicious to mankind, ſhould ever have aroſe from chemiſtry: but, what ſhall we ſay? the ſame chemiſtry would furniſh divers others vaſtly worſe and more forcible. Perhaps, it were better to be ſilent about them: but this we may affirm, that we have ſeen, and made, ſuch experiments, as to the burning and dilating of bodies, as have ſtruck us with horror and amazement. One we cannot omit, as being already known to ſeveral: Take, *e. gr.* an ounce of oil of caraways, and an ounce of ſtrong ſpirit of nitre, each in a ſeparate phial; the minute they come to be mix'd together, by the colliſion or breaking of the two glaſſes, ſuch a fume and flame will ariſe, as will catch and conſume whatever is in its way, without any poſſibility of its being extinguiſh'd *†. For it will have its full effect in water, and even *in vacuo* ||. *Hannibal* antiently overcame a powerful enemy, in a ſea-engagement, by pots full of ſnakes thrown on their veſſels, which breaking upon the ſame,

*Inextinguiſhable fire.*

"as the vapour of water out of an æolipile; the ſulphur alſo being volatile is converted into vapour, and augments the exploſion; and the acid vapour of the ſulphur, *viz.* that which diſtils under a bell, into oil of ſulphur, entring violently into the fixt body of the nitre, lets looſe the ſpirit of the nitre, and excites a greater fermentation, whereby the heat is further augmented, and the fix'd body of the nitre alſo rarified into fume, and the exploſion thereby made more vehement and quick. *Opticks*, p. 317.

* See further in *Bacon's Hiſtory*, p. 17.

† "If ſalt of tartar be mix'd with gunpowder, and that mixture be warm'd till it takes fire; the exploſion will be more vehement and quick than of gunpowder alone: which can proceed from no other cauſe but the action of the vapour of the gunpowder upon the ſalt of tartar, whereby that ſalt is rarified." *Newt. Opt. p.* 317.

This makes what they call *pulvis fulminans*, whoſe effect Sir *Iſ. Newton* in the ſame work accounts for from the great attractive force, whereby the acid ſpirits of the ſulphur and nitre ruſhing towards one another, and towards the ſalt of tartar, by the violence of the ſhock turn the whole into vapour and flame. *Ibid. p.* 352, 353.

*† On this occaſion we cannot omit to admire an inſtance of a noble and generous principle, in the late king of *France*, *Louis* XIV. A *Roman* chemiſt, *S. Poli*, having diſcovered ſomething of this kind, of prodigious effect, came to *France* in 1702, on purpoſe to make an offer of it to that prince; who, tho' he was then going to be engag'd in a war againſt a powerful confederacy; yet voluntarily renounced all the advantages of ſuch a ſecret; handſomely rewarded the inventor, but enjoined him to let it periſh. *Hiſt. de l'Acad. R. des Sciences*, *An.* 1714.

|| A drachm of compound ſpirit of nitre being poured on half a drachm of oil of caraway ſeeds *in vacuo*; the mixture immediately made a flaſh like gunpowder, and burſt the exhauſted receiver, which was a glaſs ſix inches wide, and eight inches deep. *Newt. Opt.*

infected

infected the men with their poiſon: But what might be done with a mixture of two ſuch bodies, as would burn every thing they came near inextinguiſhably?

7°, *Pyrotechny*, or the *art of fire-works*, in which the *Chineſe* are ſo excellent; (whereby, fires either fix'd, or miſſive, are contrived to exhibit all kinds of figures;) owes its riſe and all its increaſe to chemiſtry; as 'tis this art alone that furniſhes camphor, nitre, ſulphur and gunpowder, which are the chief ingredients in ſuch compoſitions. See more on this ſubject in a fine little *French* treatiſe call'd, *l'Art de Feu* *. *Artificial fire-works.*

8°, In the *art of magic*, the moſt elegant, and ſurprizing of all arts; whereby the public wonder and applauſe are ſo eaſily procured. *Magic.*

Now *magic* among the ancient *Chaldeans*, *Babylonians*, and *Perſians*, where it was principally cultivated, ſignified no more than *wiſdom*: and hence the *Sophi* of the *Greeks*, were by them call'd *Magi*, who being acquainted with many of the hidden powers of nature, directed 'em in ſuch manner as to produce effects, whoſe cauſes being unknown to the vulgar, were attributed to dæmons **. And hence the art came into an undeſerv'd diſrepute, and the magicians became cenſur'd as working by compact with the devil. But this is invidious: for in the evangeliſt *Matthew*, the magi are ſaid to have come from the *Eaſt* to worſhip *Jeſus Chriſt*; which no body imagines to be underſtood of ſorcerers. Hence *Roger Bacon* in his elegant treatiſe, *de nullitate magiæ*, undertakes a vindication of the term *magia*. See *Cardan de ſubtilitate rerum*, Fernelius *de abditis rerum cauſis*, *I. Baptiſt Porta's Magia Naturalis.*

By this art, improved and perfected by chemiſtry, ſtupendous effects may be produced; and ſuch as ſhall readily impoſe on the reſt of the world, and paſs for real miracles. Suppoſe, *e. gr.* the uſe of gunpowder unknown, except to a ſingle perſon; and this perſon ſuppoſe to dig a hole deep in the ground, and therein beſtow a good quantity thereof, with a piſtol fitted to a clock; ſo, as he could exactly know the time when the exploſion would be made. This done, if he ſhould warn the people, that on ſuch a day, and at ſuch an hour, there would be a great earthquake, and fire burſt out at ſuch a place: would not he be deem'd a conjurer? And if any body ſhould go at this day to *America*, pretending to be ſent from God, and offer ſuch a miracle in confirmation of the truth of his miſſion; would not every body believe in him? *Sham miracles produced by chemiſtry.*

Again, if any one ſhould foretel an earthquake to happen at ſuch an hour, even among us; he would be thought to deal with the devil. And yet this is eaſily done; by only taking twenty pounds of iron filings, and as many of ſulphur, mixing and working 'em together, and tempering 'em with a little water, ſo as to form a maſs, half moiſt and half dry. This being buried three or four feet under ground, in $\frac{1}{2}$ or $\frac{1}{4}$ an hour's time, will have a prodigious effect: the earth will begin to tremble, crack and ſmoke; *Earthquakes.*

* Or in *Wolfius's Element. Pyrotech.*

** See more in the account of *Bacon*, *p.* 16, 17.

and fire and flames will burst thro'. Such is the effect even of two cold bodies, in the cold ground*†.

*Phosphorus.* Chemistry, likewise, directs us to make *phosphorus* *; a little whereof being mix'd in oil of almonds, or turpentine, and the face, hands, &c. wash'd therewith; they will be seen in a dark place, to be all in a bright flame, not inferior to fire it self: yet upon bringing the candle, or coming to the light of the sun, the face, &c. will appear in all respects like those of another.

We read in sacred writings, that *Moses*'s face shone when he came out of the mount: but then it shone in the light as well as in the dark.

Suppose the magic lanthorn only known to one person; and he, while another is asleep, having made a hole in the wall of the room, applies the lanthorn thereto; so, as that the light, and one of the figures is projected on the opposite wall: the sleeper now awaking, sees a grotesque gigantic woman walking on the wall, having her head incompassed with rays, as angels are usually represented: will not he conclude he has seen a vision? and especially if some priest had foretold it? By such a stratagem was one of the first princes of *Europe* taken, not many years ago; who having no children, and being yet unwilling to make his will in favour of his nearest relation; awaking one night, saw his mother's image represented in the brightest colours on the chamber wall; so as he readily concluded his mother herself present: by which he was persuaded to make his will, and to put an end to several bloody wars he was then engag'd in, on that very occasion.

*Lightening.* By chemistry we are likewise furnish'd with a means of making an artificial flash of lightning in a room: for if a little spirit of wine be evaporated by a gentle fire out of a flat vessel, the same will be dispersed throughout the whole room: then, if any person in the night-time enter the place with a lighted candle; the spirit catching fire, the room will immediately appear all in flames, as from a sudden flash of lightning. Chemistry has likewise the art of raising a loud crack with a vehement flame, by the mere mixture of two cold liquors, *viz.* spirit of nitre, and oil of cinnamon, or oil of cloves; a quantity of which being mix'd in a glass phial, the vessel is immediately burst into a million of pieces, the room fill'd with flame and noise, and the persons present all instantly struck dead †.

*† This Sir *Is. Newton* solves on the principle of attraction, which occasions that "even the gross body of sulphur pow-"der'd, and with an equal weight of iron "filings, and a little water, made into "paste, acts upon the iron, and in five "or six hours, grows too hot to be touch'd, "and emits a flame. *Opt. p.* 354.

* See more of this in the chapter *of fire.*

† "Oil of vitriol being drawn off from "its weight of nitre, and from both the "ingredients a compound spirit of nitre "distill'd; and two parts of this spirit "poured on one part of oil of cloves, or "caraway seeds, or of any ponderous oil "of vegetable or animal substances, or "oil of turpentine thicken'd with a lit-"tle balsam of sulphur; the liquors grow "so very hot in mixing, as presently to "send up a vehemently burning flame: "Does not this great and sudden heat ar-"gue that the two liquors mix with vio-"lence, and that their parts in mixing run "towards one another, with an accelera-"ted motion, and clash with the greatest "force? *Newton, ubi supra.*

We have a glaſs ſo prepared, as that upon the ſmalleſt ſtroke, nay a ſlight touch of the finger, it emits flame: now if a ſtatue were caſt thereof, and placed in a church, it would ſhew a world of miracles. *E. gr.* if a man begging of the prieſt a remiſſion of ſins, were ordered to go to church, and make his prayers and vows before ſuch a ſtatue; after which, in caſe he were pardoned, upon touching a finger of the ſtatue, fire ſhould break out as from heaven: would not this be a miracle worth the regiſtring?

From the whole it appears, what ſurprizing effects a perſon skill'd in chemiſtry, and knowing how to uſe the powers of nature, may produce.

9°, *In the culinary art*, which is chiefly converſant in the preparation of meats, *viz.* the ſeaſoning, pickling, *&c.* to prevent 'em from putrifying, growing muſty, breeding maggots, *&c.* *Cookery.*

Here, too, chemiſtry ſhews it ſelf: we ſhall only inſtance one thing; *viz.* ſpirit of ſalt, which is of ſo vaſt importance to ſea-faring people, when thro' ſcarcity of proviſions, they are oblig'd to eat muſty, putrified, or infected meats, that it prevents all diſeaſes which would accrue therefrom. For, only waſhing ſuch meat in ſpirit of ſea-ſalt, and the ſpirit inſinuates it ſelf with in the pores of the fleſh, purges off the rottenneſs, or the muria, and prevents the ſcurvy. *Uſefulneſs of ſpirit of ſea-ſalt.*

*Joh. Rudolph. Glauber* ſhews how every body may carry about with 'em, in a phial, what will render all their corrupted eſculents, and potulents, eatable, and drinkable; even corrupt water, *&c* ||. He aſſures us, that this ſame ſpirit is the moſt powerful and univerſal corrective in all medicine; and inſtances of what infinite uſe it might be in towns beſieged, where the people living moſtly on putrified meats, and being unable to bear 'em, ſoon die. Whereas were they to waſh, and elixate their meats, with a due quantity of ſpirit of ſea-ſalt, the putrid fœtor would be eliminated, their ill qualities corrected, and they rendered wholeſome food.

10°, *The art of making wines* of all kinds, is wholly owing to chemiſtry, which firſt ſhew'd the uſe of fermentation, and directed the raiſing, abating, promoting or extinguiſhing thereof. *Making wines.*

By *wines* we mean the juices or liquors of vegetables rais'd by fermentation to a vinous quality; *i.e.* a quality whereby when expoſed to the fire in a chemical veſſel, a ſpirit immediately ariſes from the ſame, which is inflammable and miſcible with water, and denominated *ſpirit of wine* †.

Now ſuch wine may be obtained from any vegetable, and in ſuch ſpirit reſides all the calefactive or warming power of the vegetable. Thus the vine, the apple, the pear, plum, cherry, and other cold plants and fruits; by fermenting, yield warming wines; and thus *England*, a country not the beſt diſpoſed for the ripening of grapes, prepares it ſelf wines from bar- *Wine and ſpirit yielded by all plants.*

|| Hitherto may be referr'd the methods of judging of the ſalubrity of water, and of making ſalt-water freſh, and potable, *&c.* delivered hereafter in the chapter *of water.*

† This will be conſidered at large in the *hiſtory of fermentation.*

ley;

ley, and other corn-fruits, which yield excellent vinous ſpirits, in no reſpect different from thoſe of diſtill'd *French* or *Spaniſh* wines.

*The ſame ſpirit of wine procurable from all plants.*

The truth is, there ſcarce appears any difference in this reſpect, whatever vegetable you make uſe of: the ſame ſpirit is yielded by all, without excepting even graſs. All the choice reſts here, that ſome yield a deal more ſpirit than others. Now the drawing, fermenting, fining, *&c.* belong all to chemiſtry.

11°, *In the art of brewing*, or preparing malt liquors, which is an art a thouſand years old; and its invention aſcribed by *Herodotus* to *Iſis*, who upon wandering over divers parts of the earth, taught people the art of preparing malt-liquors: *Tacitus*, alſo, in his book *de moribus Germanorum* *, aſ-

* *Matthiolus* takes the *zythum*, and *curmi*, to be the ſame with the *beer* or *ale* drank in *England*, *Germany*, &c. and that the only difference between the zythum and curmi lay in the manner of the preparation, which render'd 'em either weaker or ſtronger. In a famous diſpute at *Paris*, in the year 1668, on the ſubject of the bakers uſing the yeaſt of ale and beer to leaven their dough, Meſſ. *Patin*, *Brayer*, *Blondel*, and *Courtois*, ſpeak of that liquor in the following terms: "Beer, ſays *Corn.* "*Tacitus*, that unhappy beverage, made of "hops, and wheat or barley, corrupted "with damaged water, was no ſooner diſ"covered than it was condemned by *Dioſco*"*rides*, *Galen*, and other of the greateſt phy"ſicians. They all charg'd it with preju"dicing the head, nerves, and membranous "parts, of vitiating the animal juices, and "of cauſing a more obſtinate and painful "drunkenneſs than wine." Other phyſicians vindicated it, particularly Meſſ. *Perrault*, and *Rainſſant*; who, among other things, inſiſted that "the hop was not a noxious "herb, but, on the contrary, had apparent"ly the faculty of cleanſing the blood, and "removing obſtructions; and that it was "added to the modern beers to correct the "ill qualities charged on the beer of the "antients, which differed from ours in that "it was made without hops."

In order for brewing, the barley is firſt to be made into *malt*; which is done by putting it into a ciſtern full of water wherein it may ſwim, for a longer or leſs time, as the weather is more or leſs cold; two days and nights ſufficing in hot weather, and five or ſix in extremely cold: when ſufficiently ſteep'd, the water is drain'd off, for twelve or twenty hours; then, being taken out, it is couch'd or heap'd up into one or two heaps, and turn'd every five or ſix hours, the outermoſt part inwards, and the bottom upwards. As it *comes* or ſprouts, it is ſpread thinner to cool, and prevent its coming too faſt: when come, it is ſpread very thin, and turn'd twelve or twenty times a day, till the ſprout is dead: then it is again thickned on the floor, and turn'd as before; great care being taken that it neither mould nor become *acro-ſpired*, that is, that the blade don't grow out at the end oppoſite to the root, or the malt come and ſprout at both ends. The preparation is finiſhed with drying it on the kiln, by ſpreading it on a hair-cloth, or a tin bottom full of holes, over a briſk turf, or charcoal fire; ſtirring and turning it from time to time.

Now to proceed to the *operation of brewing* it ſelf, they boil a quantity of water, and pouring enough of it upon the malt, in a maſhing tub, to wet the malt as ſtiff as it can be well rowed about; after ſtanding a quarter of an hour, another portion of water is added, and the rowing repeated: laſtly, the full quantity of water is added, according to the intended ſtrength of the beer or ale. The whole having ſtood two or three hours, is drawn off into a receiver, and freſh water thrown on for a ſecond wort; which is to be cooler, and to ſtand leſs time than the former. The two worts being mix'd, and the hops added, the whole is put into a copper well covered, and clos'd, there to boil an hour or two. Which done, the liquor is let into a receiver, and the hops ſtrained therefrom: when cold, the barm is added, and after fermenting or working, it remains to be tunn'd up.

ſures

ſures us, that thoſe people uſed, of antient time, to extract wine from putrified corn: but there is no brewing without fermentation; and 'tis chemiſtry directs the manner of fermentation. *Iſis*, therefore, in this light, appears to be the firſt chemiſt.

But there is no end of the mechanical uſes of chemiſtry: all we here do, is to pick a few inſtances out of an infinity: half the things in common life are the effects of this art; and the ſame art is an endleſs ſpring of infinite others. Would the chemiſts apply themſelves each to his ſeveral art; there is no doubt but they would readily outſtrip all other artiſts, and bring their reſpective arts to the laſt perfection.

## *Uſes of Chemiſtry in Alchemy.*

THE fourth uſe of chemiſtry is in alchemy. Now alchemy is an art, which teaches means unknown to common chemiſts, whereby to make gold: theſe means are, 1°, By *ſeparating* and bringing forth the latent gold. 2°, By *ripening*, and perfecting the crude, indigeſted gold. 3°, By *tranſmuting*, or changing other metals entirely into gold. *Divers means of making gold.*

The firſt, is that wherein the moſt viſible ſucceſs has been met withal. 'Tis now paſt all controverſy, that all metals whatever contain gold: there is ſcarce any ſilver, any lead, any copper, any iron, *&c.* but gold is found in it*, only 'tis uſually in ſo ſmall quantity, that it does not prove worth while to get it out. *By ſeparation.*

The ſecond, by *maturation*, has likewiſe been proſecuted to good purpoſe: we know what the matter or baſis of all metals is, *viz.* mercury; and this mercury beginning to purge it ſelf of its ſulphur, firſt aſſumes the metallic nature. As it purges further and further, it inſpiſſates and hardens more and more; till having paſt thro' all the ſtages of the leſs perfect metals, it becomes gold ‖. *By maturation.*

Some *Adepti* add, that gold is not ſo created; but grows from a ſeed; after the ſame manner as a tree is not ſaid to be created, but is produced from a ſeed, and increaſes by degrees to ſuch a bulk. As plants, then, have their ſeed whereby they are propagated; ſo has gold its ſeed, which, where it meets with a proper pabulum, grows and thrives: and again, as the firſt juice of a plant is crude and imperfect, ſo is gold in its firſt orign.

Now we don't ſee why this art ſhould be abſolutely pronounced falſe: one inſtance may let you a little into its merits: take an ounce of pure ſilver, and diſſolve it in *Aqua fortis*, and you will get a grain of pure gold out of the ſame. Fuſe the ſilver by fire, evaporate the *Aqua fortis*, and diſſolve the ſilver a ſecond time in *Aqua fortis*, and you will have another grain of gold. This you may repeat as often as you pleaſe, and every time you will get a freſh grain of gold: which ſhews that the fire produces or ripens gold out of ſilver.

The third branch of alchemy teaches how to make gold of other metals; which all the world cries out is impoſſible; tho' we don't ſee why: 'tis certain, that the matter of all metals is the ſame, *viz.* mercury, which *Tranſmutation.*

* See *p.* 81, 86, in the notes.

‖ See further in *p.* 101, 102.

may

may be procured equally heavy from all metals. If then a body could be found, which would consume all the heterogeneous part of metals; and leave the pure mercury fixed alone, we should readily make gold. But the philosophers stone is said both to render the foreign heterogeneous parts volatile, and to fix mercury; so that the transmutation of metals does not appear impossible.

*Philosopher's stone.*

*Its characters.*

The alchemists, therefore, search for the philosophers stone, which they describe as a ponderous substance, of a ruby colour, as friable as glass, and as fusible in the fire as wax, and yet more fixed therein than gold: now a little of this, say they, thrown or poured on the baser metals, when in fusion, presently penetrates the metallic matter, makes the fæces or impurities retire therefrom; and these it burns and renders volatile, so that they fly off; and the rest of the mass is immediately turn'd, or transmuted into gold. This stone, in reality, appears to be no other than the fixing sulphur, or *sulphur metallorum*, i. e. that part in gold which fixes and coagulates the mercury into pure metal, that part we mean, vivifyed or render'd vital, and increased, and exalted *.

*Effects.*

*The same with the fixing sulphur.*

*Helmont* asserts, that he was master of this secret; thus: "I have seen "the philosopher's stone; which a person of no longer than a night's acquain- "tance put into my hands; and which I my self have seen convert a whole "mass of lead into gold: and I could quote a croud of persons, kings, "princes, knights, &c. who will attest that they have seen the same "transmutation." † Now these, whom *Helmont* quotes as evidences of the transmutation, we will allow might be imposed on; but he himself, a knowing, and sagacious chemist as he was, could scarce be so deceived: so that he must either be doom'd a lyar, or we must allow the transmutation.

This we can affirm from our own experiments, that the purest mercury found among us, has something in it that is not mercury; which taken away, the rest approaches nearly to the weight of gold: 'tis certain, a long and tedious operation is necessary to purge mercury entirely; but the further you go, still the more subtle, and purer, and heavier, till at length it equal gold it self in weight. Now, if to mercury thus purified, you can give the proper digestion, in proper degrees; the mercury will become gold: to make gold, therefore, there are only two things required, *viz.* first, a consumption of impurities; and second, a fixing or converting of a fluid into a malleable solid. Now, why should the first be held impossible, when we see that lead, in a few minutes, carries off every thing except gold, and silver; and antimony, all except gold? Whether the thing be possible, or no, we will not say: but since the alchemists in other things, wherein they can be understood, use to speak the truth; they deserve some credit in this.

*Requisites to the making of gold.*

* See *p.* 100, 103.

† Further instances, and authorities, may be seen in the notes, *p.* 43, 44.

The

The alchemifts only pretend to do that in a lefs time, which nature does in many years: for lead and gold don't differ much as to weight; confequently there is not much in lead befide mercury. Now 'tis certain there is gold in every mafs of lead: had we then a body which would fo agitate all the parts of lead, as to burn every thing out but mercury and gold; and had we fome fixing fulphur to coagulate the matter remaining: would not it be gold? Why then fhould the alchemifts be fo derided? tis from a mere ignorance of the nature and philofophy of metals. The philofopher's ftone is held a fix'd, fubtle, concentrated fire, which upon its melting with metals, does, by its magnetic power, immediately unite it felf to the mercurial body of the metals, feparates all that is impure therein, volatilizes it, and leaves the reft pure mercury. *Tranfmutation and the Philofopher's ftone no impoffibilities.*

Where is the impoffibility? for our own parts we neither affirm nor deny it: but this we may reft fecure of, that if any body has the fecret, he won't difcover it to another, fo that all who pretend to have it, and to fell it others for money, plainly fhew they have it not. We can't forbear however, to fay, that the genuine *Adepti* have faid nothing fo abfurd; nor is Mr. *Boyle* himfelf averfe to the notion: *Helmont* fays he faw it and felt it; that a friend of his gave him $\frac{1}{4}$ of a grain of this ftone, which he added to 8 ounces of melted filver, and the filver was turn'd into gold, all but 14 grains, which went off in fume: and he fays the like of lead, only a greater quantity thereof was loft. Now if we read the alchemiftic authors, we find nothing of iron or copper thus converted into gold; whereas were the whole a deceit, it had been as eafy to have taken thofe metals too into the account. But the philofopher's ftone is never applied to any thing but filver, lead and mercury. Other philofophers laugh at 'em for calling the philofopher's ftone a fix'd, concentrated fire; as thinking it a contradiction, that fire, which is the moft volatile of all bodies, fhould be call'd *fix'd*. But fuch people are unacquainted with the nature of fire, nor have feen the experiments wherein we catch, hold, bind, and weigh fire, extract it out of bodies, introduce it into bodies, and retain and fix it therein*.

A fecond thing the alchemifts feek, is a *ferment; of the philofopher's ftone*, i. e. fuch an exaltation of this ftone, as that if it be fufed with gold, it will convert that metal into this ftone; which they call the *multiplicative power*. *Multiplicative virtue of the philofopher's ftone.*

A third thing they are in fearch of, is an *univerfal ferment*, that is, fome artificial matter, which being applied to any feed, increafes its fecundity to infinity: thus if it be applied to gold, it changes the gold into the philofopher's ftone of gold; if to filver, it converts it into the philofopher's ftone of filver, *i. e.* into a matter which tranfmutes every thing into filver: if to a tree, the refult is the philofopher's ftone of the tree, which tranfmutes every thing into the fpecies of trees, and fo of the reft. *An univerfal ferment.*

This, a noble traveller, far from all temptations from want of money, affured us he was mafter of; its intention is to increafe the kinds of all things, *v. gr.* fo to increafe the quantity of wheat, as that the fpace now

* Of this fee more in the chapter *of fire.*

 poffeffed

poſſeſſed by all things in nature, ſhould be taken up by wheat alone. But this ſeems repugnant to the rules of nature; it being a moſt certain truth, that a *ſeminal fabric is only to be had from a ſeed.* This ſpeculation, therefore, we are but little inclined to give into.

Theſe three things are all we could collect from all the alchemiſts who have ever wrote; and of theſe the making of gold is held much the leaſt noble arcanum. With regard to which, it is their unanimous doctrine, that mercury is the ſame in all metals, only differing in degree of purity; being pureſt in gold, and in the reſt ſo much the purer as the metal is purer: that mercury is the immediate matter of gold; and that if all the ſcoriæ adhering to mercury, be taken away, it will become heavier than gold it ſelf; and in that ſtate is call'd mercury of metals.

## *Of the* INSTRUMENTS *of Chemiſtry.*

WE are now to conſider the *inſtruments*, by the application whereof chemiſtry performs its operations.

The whole theory of chemiſtry, we have already obſerv'd, is laid down in the mere explanation of its definition; all the parts whereof are already gone thro': excepting the laſt, which ſtill remains to be explained, *viz.* by what means the changes wrought in bodies by chemiſtry, are effected.

*An inſtrument, what.* An *inſtrument*, then, is a certain body, by whoſe application to ſome other body, a motion is excited therein, by which motion the change intended by the art is produced*.

*Inſtruments of chemiſtry reducible to ſix.* All the inſtruments of chemiſtry may be reduced to ſix; the four firſt whereof, are the four vulgar elements.

The 1°, is *fire*, by which all motion is produced.

2°, Is *air*, by means whereof motion is preſerved.

3°, Is *water*, by which motion is communicated.

4°, Is *earth*, whereof all veſſels are made.

5°, Are *menſtruums*, whereby bodies are intimately diſſolved and mov'd.

6°, Are *veſſels*, wherein the bodies to be changed by fire, water, &c. are contained.

* Or, an *inſtrument* is a body which eaſily receives certain motions from other bodies, and applies 'em to the ſubjects intended to be changed; producing ſuch effects therein, as the art propoſed. *Boerhaave, cod. impreſſ.*

By

By *fire* we mean any body that rarifies the air in a thermometer: this fire is the univerſal inſtrument of all nature, as well as of the art of chemiſtry. By this it is, that all bodies are moved, and it is by this that they diſcover their powers: If this were away, all bodies would immediately become ſolid and immoveable. Now there is no chemical operation without fire; as is evident hence, that there is no place, no body but has fire in it; and that it is abſolutely impoſſible to exclude the fire out of any body whatever. *Fire.*

*Air*, 'tis true, we can exhauſt to any degree at pleaſure, by the air-pump; and in the *Torricellian* experiment, it is ſometimes drawn out, ſo as not to leave any ſenſible reſiſtance: in which caſes, there is phyſically no air at all. But we have no ſuch operations in chemiſtry: the air has a ſhare in 'em all; as having continual ingreſs and egreſs out of all our veſſels, and as being included in the pores of all bodies. Air then is preſent in all our operations, and occaſions a great change therein, by its power of rarifying, and contracting every moment, and by its alternate vibrations, whereby all bodies are kept in continual motion. *Air.*

*Water* is ſcarce capable of being excluded out of any place, or body; for the drieſt, and warmeſt air, contains water; and the particles of air are in reality ſo many magnets, which are continually imbibing water, whatever place they are in. Nay, if the air be exhauſted out of a receiver, the water is in good meaſure left behind; and little drops are found to fall to the bottom: the remaining air being ſo rarified, as not to be able to ſuſtain the water. *Water.*

*Earth* is preſent in all our operations, as being the matter whereof all our furnaces, veſſels, glaſſes, fuel, &c. conſiſt. *Earth.*

The doctrine of each inſtrument of chemiſtry we ſhall now lay down a-part.

THE

# Hiſtory of FIRE.

*Fire held a deity.*

THE nature of fire is ſo obſcure, and wonderful, that it was held by moſt of the antients, as a Deity. Great pains have been taken by ſeveral authors, of prime note, to unveil this myſterious Being ; but after a careful peruſal of what they have done, we find them all ſtick by the way, unable to explain many of the principal effects and phænomena thereof.

To get over this, we have been at no ſmall pains in making a new ſet of experiments, wholly with this view ; and on the footing thereof, have laid down a new doctrine of *fire*, in a courſe of public lectures held for that purpoſe : The reſult whereof, we ſhall here deliver in a little compaſs *.

*The inſtrument of all motion.*

Fire, in effect, appears to be the general inſtrument of all the motion in the univerſe : the conſtant tenor of a great number of experiments made to this purpoſe, leave us no room to doubt, but that, if there were no fire, all things

* The doctrine of fire here laid down by our author, will appear new and extraordinary ; at leaſt among us, who have been uſed to conſider fire in the light it is ſet by my Lord *Bacon*, Mr. *Boyle*, and Sir *I. Newton*. But whatever veneration we may owe to thoſe illuſtrious authors, we ſhould be inexcuſable, even in their judgment, ſhould we abſolutely acquieſce in what they have done, and ſhut the door againſt further, or even better, information. *Boerhaave* may be eaſily ſuppoſed to have gone beyond any of them ; in that, beſide all the experiments and obſervations which they had to build on, he has the advantage of a new ſet they were unacquainted withal. However, as his experiments are not yet made public ; and as, for want thereof, there appear divers things in this chapter, which may be call'd in queſtion : we would not give it alone ; but along with his ſentiments, and ſolutions, have choſe to give the correſponding ones of the other philoſophers, both

things would inſtantly become fix'd, and immoveable. Of this we have popular inſtances every winter: for while froſt prevails, the water, which before was

both where they agree and corroborate, and where they claſh with each other.

The great, and fundamental difference in reſpect of the nature of fire, is, whether it be originally ſuch, form'd thus by the creator himſelf at the beginning of things; or whether it be mechanically producible from other bodies, by inducing ſome alteration in the particles thereof? Among the modern writers, *Homberg*, *Boerhaave*, the younger *Lemery*, and *s'Graveſande* maintain the former: the latter is chiefly ſupported by the *Engliſh* authors.

*Bacon*, in his treatiſe *de Forma Calidi*, deduces from a great number of particulars, that heat, in bodies, is no other than motion; only, a motion ſo and ſo circumſtantiated: ſo that, to produce heat in a body, nothing is required but to excite ſuch motion in the parts thereof.

*Boyle* ſeconds him, in an expreſs treatiſe of the *Mechanical Origin of Heat and Cold*; and maintains the ſame doctrine with new obſervations and experiments: As a ſpecimen, we ſhall here give one or two of them. Many more will come in the courſe of the chapter.

"In the production," ſays he, "of heat, there appears nothing on the part either of the agent or patient, but motion, and its natural effects. When a ſmith briſkly hammers a ſmall piece of iron, the metal thereby becomes exceedingly hot; yet there is nothing to make it ſo, except the forcible motion of the hammer, impreſſing a vehement, and variouſly determined agitation, on the ſmall parts of the iron, which being a cold body before, grows, by that ſuper-induced commotion of its ſmall parts, *hot*: Firſt, in a more looſe acceptation of the word; with regard to ſome other bodies, compared with which, it was cold before: then, ſenſibly hot; becauſe this agitation ſurpaſſes that of the parts of our fingers: and in this inſtance, oftentimes, the hammer and anvil continue cold, after the operation; which ſhews, that the heat acquired by the iron, was not communicated by either of thoſe implements, as heat; but produced in it by a motion, great enough ſtrongly to agitate the parts of ſo ſmall a body as the piece of iron, without being able to have the like effect upon ſo much greater maſſes of metal, as the hammer and the anvil.* Tho' if the percuſſions were often, and briſkly renewed, and the hammer were ſmall, this alſo might be heated. Whence it is not neceſſary, that a body itſelf ſhould be hot, to give heat.

"If a large nail be driven by a hammer into a plank of wood, it will receive ſeveral ſtrokes on its head, e'er it grow hot; but when it is once driven to the head, a few ſtrokes ſuffice to give it a conſiderable heat: for while, at every blow of the hammer, the nail enters further into the wood, the motion produced is chiefly progreſſive, and is of the whole nail, tending one way; but when the motion ceaſes, the impulſe given by the ſtroke, being unable to drive the nail further on, or break it, muſt be ſpent in making a various, vehement, and inteſtine commotion of the parts among themſelves; wherein the nature of heat conſiſts." *Mech. Produc. of Heat and Cold.*

Agreeable to this, is the opinion of Sir *I. Newton*, who conceives that "groſs bodies may be converted into light by the agitation of their particles; and light, again, into groſs bodies, by being fixed therein." *Optic.* p. 318, & 349.

On the other hand, M. *Homberg*, in his *Eſſai du Souffre Princip.*, holds, "that the chemical principle or element ſulphur, which is ſuppoſed one of the ſimple, primary, pre-exiſtent ingredients of all natural bodies, is real fire; and conſequently that fire is coeval with body." *Mem. de l'Acad. An.* 1705.

Dr. *s'Graveſande* goes on much the ſame principle: "Fire, according to him, enters "the

*Absence of fire the cause of freezing.*

was fluid, by a mere privation of heat, becomes solid, *i. e.* hardens into ice *, and so remains till resolved again by fire. That the difference between water which freezes, and other water which does not, consists in the different quantity of fire contain'd in the one, and the other, appears hence; that if you apply a thermometer alike to a vessel full of cold water, inclining to freeze; and to another vessel full of water, one degree nearer freezing: you will find the former to have a greater degree of heat than the latter: And if a quantity of ice and sal-gem were added to either, the water would be still found much colder, and accordingly more disposed to freeze. And if from this water you remove the thermometer to the other less cold, the spirit will rise; the cause of which rising can be no other than the little fire still remaining in the water: or, to speak more precisely, the cause of the spirits being rarefied and elevated higher by the one than the other, is no other than the greater remains of fire in this, than that †. In effect, all natural motion is perform'd either by a separating of parts from each other, or by a rarefying of them; neither of which is done, but by fire.

*Shewn by the thermometer.*

*Air, plants, and animals without fire would fix into rigid masses.*

'Tis therefore a just observation of the chemists, that *fire is the universal cause of all the changes in nature:* Thus, were a man entirely destitute of heat, he would immediately freeze into a statue. And thus, the air itself, which is found in continual motion, being always either expanding or condensing, would, upon the absence of fire, contract itself, so as to form a solid, consistent vault. So, also, all animals and vegetables, all oils, salts, *&c.* would upon the like occasion immediately congeal.

That fire is the real cause of all the changes in nature, will appear from the following considerations.

"the composition of all bodies, is contain'd "in all bodies; and may be separated, or "procured from all bodies, by rubbing "them against each other, and thusputting "their fire in motion. But fire, he adds, "is by no means generated by such mo-"tion." *Elem. Phys.* t. 2. c. 1.

M. *Lemery* the younger agrees with these two authors in asserting this absolute, and ingenerable nature of fire: But he extends it further. Not contented to confine it as an element to bodies, he endeavours to shew that it is "equably dif-"fused thro' all space, is present in all "places, in the void spaces between bodies, "as well as in the insensible interstices be-"tween their parts. *Mem. de l'Acad. An.* 1713.

This last sentiment falls in with that of *Boerhaave*, which will be more largely set forth in what follows.

* *Paracelsus* even affirms rock-crystal to be nothing else but water strongly congeal'd by a very intense cold. But this does not appear very probable, in regard crystal is so much heavier than water; whereas ice is lighter. See the chapters of *Stones* and *Water*.

† Accordingly, the younger *Lemery* observes, that ice is only a re-establishment of the parts of water in their natural state; that the mere absence of fire is sufficient to account for this re-establishment: and, lastly, that the fluidity of water is a real fusion, like that of metals exposed to the fire; only differing in this, that a greater quantity of fire is necessary to the one than the other. *Mem. de l'Acad. Royal. An.* 1709.

1°, Under the word *nature*, ſome conceive all created Beings; but in the ſenſe we here uſe it, it only extends to *body*, or the aggregate of all bodies; any change wherein, we aſſert to be impoſſible, without the mediation of fire: For all bodies are either ſolid or fluid; the ſolid, of themſelves, are commonly ſuppoſed to be inactive, and motionleſs; the fluid both move, and are moved †. *Fire the cauſe of all changes.*

Now even all ſolids are found ſo much the more firm and contracted, as they have the leſs fire; as is evident in iron, which, when heated, expands into a much greater ſpace than when cold ||. So that any ſolid, and hard body, by being freed of all fire, would ſink into a much leſs bulk, and its parts cohere more nearly, and with greater force than before. Nay, Mr. *Boyle* ſuggeſts ſeveral conſiderations why even the moſt ſolid bodies ſhould be thought to have an inteſtine motion. This he inſtances particularly in a diamond he wore, which had a ſpot in it, that he could ſenſibly perceive to change its place. This would bring ſolids ſtill nearer to the condition of fluids. *In ſolids.*

† 'Tis not a point univerſally agreed on, that fluidity conſiſts in a perpetual motion of the parts of a fluid body. The *Carteſians*, 'tis true, take it for granted; and, accordingly, make this the definition of a fluid, that it is a body whoſe minute parts are in a continual agitation. But this appears a little too adventurous; as we cannot directly prove that there is ſuch motion in all fluids. Sir *I. Newton*, therefore, proceeds more cautiouſly: To conſtitute a fluid, he only ſuppoſes it neceſſary "that the particles be eaſy to put "in inteſtine motion, and in moving be diſ"poſed to ſlide over one another". Indeed, this amounts to much the ſame, with regard to our preſent purpoſe, as the former: for, here, ſuch a lubricity, volubility, and mobility of the parts is ſuppoſed; as, conſidering the almoſt inceſſant agitations of the earth, air, &c. and the actions of the fire, &c. which will be ſhewn to penetrate all bodies; can ſcarce poſſibly let the particles of any fluid in nature, remain one moment in a ſtate of reſt. Accordingly, Dr. *Clark* takes in both opinions into his notion of fluidity: "If "the parts of a body," ſays he, "either "do not touch one another, or eaſily "ſlip over one another; and be, withal, "ſo ſmall, as to be capable of being eaſi"ly agitated by heat; and the heat be "ſufficient to agitate them, tho', per"haps, not ſufficient to prevent their "freezing: or even if they be not moved, "provided they be but ſmall, ſmooth, "and voluble, of ſuch figure and bulk, "as makes them liable to be eaſily put "in motion: that body is fluid." *Annot. in Rohault. Phyſ.*

To ſay no more; the great Mr. *Boyle* lays down an inteſtine agitation of the conſtituent particles of a body, in various directions, either by an innate activity of their own, or by the action of ſome thinner medium that penetrates their pores, as abſolutely requiſite to fluidity. And tho' the particles here ſuppoſed to move, be too ſmall to have their motions obſerved by the eye; yet that author ſuggeſts ſeveral conſiderations, to evince the reality thereof: The principal things he inſiſts on, are the ſenſible operations of fluids; for how, ſays he, ſhould they effect thoſe ſolutions, putrefactions, &c. which we daily obſerve from them, without local motion? 'Tis true, a later philoſopher accounts for thoſe ſolutions, without ſuppoſing any antecedent motion in the parts of the fluid. 'Tis ſufficient, with him, to have a motion occaſionally excited by the mutual attraction between the parts of the fluid, and thoſe of the body diſſolved thereby. *Newton. Optic.*

|| "Fire," ſays Dr. *s'Graveſande*, "natu"rally unites itſelf with bodies: And "hence it is that a body brought near to "the fire, grows *hot*; in which caſe it al"ſo expands or ſwells; which expanſion "is not only obſerved in very ſolid bodies, "but in thoſe whoſe parts do not cohere; "in which caſe they likewiſe acquire a "great degree of elaſticity, as is obſerved "in air and vapours." *Element. Phyſ.*

As

*In fluids.* As to fluids, they all harden, even to the eye, upon the abſence of fire: Thus water, in a ſevere winter's cold, will form itſelf into a ſolid glebe; and yet even then, contains a great deal of fire; as evidently appears, upon application of the thermometer thereto, which is capable of falling twenty diviſions lower, e'er it arrive at the point of intenſeſt cold: And hence it is that the ſpirit of wine is kept from freezing in the thermometer; which would undergo the common fate of other things, were the fire in leſs abundance. Thus, the ſame degree of cold wherewith oil of olives congeals, does not freeze water: And yet water freezes, when ale will not *. Hence it is evident, that if there were no fire in nature, all bodies, both ſolid and fluid, would remain for ever at reſt, and conſequently never undergo any alteration.

So, the air itſelf, by a greater quantity of fire, expands; and condenſes by a leſs †: yet, where 'tis moſt of all contracted, it ſtill contains a large ſhare of fire, as is evident from the colliſion of a flint, and ſteel || therein, which is followed by ſparks of fire. If this fire could likewiſe be taken from the air; it would become ſolid, and perfectly at reſt, and conſequently incapable of change.

As, then, fire can render the moſt ſolid bodies, as ſtones, metals, *&c.* fluid, (which we evidently find in the large burning-glaſſes, wherein gold itſelf immediately calcines, and emits fumes, *i. e.* becomes fluid;) ſo the want of fire would convert the moſt fluid bodies, as ſpirit of wine, *&c.* into ſolids **.

And

* "Tho oil of vitriol be one of the moſt "fiery liquors yet known, and even performs ſome of the operations of fire itſelf, and thaws ice ſooner than the ſpirit of wine, or any other liquor; yet "having put a pound of fine rectified oil "of vitriol into a ſtrong glaſs-vial proportionable to it, we found, that, except a little which was fluid at the top, "it was all congealed or coagulated into "a maſs, like ice, tho' the glaſs ſtood in "a laboratory, where a fire was conſtantly kept not far from it, and where "oil of vitriol very ſeldom, or never, has "before, or ſince, been obſerved to congeal ſo much as in part." *Boyle Mech. Prod. of Heat.*

† *See the chapter of air.*

|| Sir *Iſaac Newton*, and the *Engliſh* philoſophers, account for the fire ariſing upon ſuch colliſion, on a different principle. They ſuppoſe it produced by putting the ſulphurous particles of thoſe two bodies in a vehement vibratory motion; by virtue of which motion, they become hot and lucid, *i.e.* affect us with the ideas of heat and light. But this doctrine will be further conſidered and explained hereafter.

** Fire, thus, being acknowledged the inſtrumental cauſe of all motion; it remains that itſelf be moved: nay, to move, muſt be more natural, and immediate to fire, than to any other body; and, hence, ſome have ventured to make motion eſſential to fire: But as this is inconſiſtent with the notion of matter, which is defined to be inert, and paſſive; and as we ſhall hereafter prove that fire is material: we muſt rather agree, that the motion of fire itſelf is derived from ſome other higher, and more metaphyſical cauſe. A property of perpetual mobility may indeed be ſuperadded to the other properties of fire; but it has no natural, neceſſary connection with them: nor can it be maintain'd with them otherwiſe than by ſome extrinſic efficacy of a ſuperior cauſe.

However, that it is by motion that fire produces its effects, is evident. And hence the action of fire cannot make any alteration

And hence we gather, that fire is the only *active* or *proper instrument of chemistry*; without which, the chemist would be absolutely incapable of performing or producing any thing.

Now, fire is two-fold; the one pure, and *elementary*; which alone we here call *fire:* the other *vulgar*, raised and kindled from the former; which is what agitates and affects ignited, combustible, and moveable bodies. *Fire distinguished.*

All the authors who have wrote of fire, overlook this distinction, which has led them into grievous mistakes: insomuch that most of them hold the flame of a piece of wood to be all fire; which is absolutely false †, as will appear from what follows.

1°, Fire may be present, in the greatest abundance, yet without any heat; as is evident in the tops of the highest mountains illumined by the sun, *Fire without heat.*

ration in the elementary substance of bodies; for it is necessary, that what acts upon an object, be without that object; *i. e.* the fire must not penetrate the elementary parts, but only enter the pores and interstices of bodies: so that it does not seem capable of making those transmutations which Sir *Isaac Newton* ascribes to it; of which we shall speak hereafter.

In effect, as to all our purposes, it may perhaps be said, that fire is always in motion: Take, for instance, six several sorts of thermometers, and two vessels of water with sal-ammoniac mixed therein; and apply the thermometers hereto: the consequence will be, that the air being condensed in them, the spirit will descend in all: Remove the vessels of water; and the air growing warmer, and so rarefying, the spirit will ascend again. So that the active force in air which produces so many effects, does really all arise from the fire contained in it.

Again, as all bodies placed in a very cold air, do, by degrees, grow cold, motionless, rigid, *&c.* tho' there be still some remains of fire; and in proportion as that is diminished, the effect is accelerated: it follows, that cold, *i. e.* a less degree of heat, is the effect of a lesser action of fire. And so all action apparently arises from the same source.

† "The flame of a body," Sir *I. Newton* observes, "is only the smoke thereof "heated red hot; and the smoke is only "the volatile part of the body separated "by the fire. Thus, all inflammable bodies, as sulphur, oil, wax, wood, *&c.* "by flaming, waste, and vanish into burning smoke; which smoke, if the flame "be hastily put out, is very thick, and "visible, and sometimes smells strongly, "but in the flame loses its smell by "burning; and, according to the nature "of the smoke, the flame is of this or "that colour. Thus, the flame of sulphur is blue; that of camphor, white; "that of tallow, yellow, *&c.* When "gun-powder takes fire, it goes off in a "flaming smoke; the explosion arises "from the violent action of its ingredients, nitre, sulphur, and charcoal upon each other; whereby the mixture "being suddenly, and violently heated, "becomes rarefied, and converted into "fume; which, by the violence of that "action becoming hot enough to shine, "appears in the form of flame. *Ibid.*

"Flame I take for a mixture of fire "with the oily part of the fuel; and this "oil, being the sulphurous part of the "mixt, *i. e.* the part wherein the fire "acts, is more disposed than any other "part to admit and retain a quantity "thereof. A quantity of fire, then, being enter'd into such oil, must extend its "mass, and augment its bulk inasmuch "as the oil is capable of stretching, and "of filling, at the same time, all the interstices thereof with its own substance. "Thus the mixture becomes what we "call *flame*; which, therefore, is an oily "body without pores, or whose pores "are exactly filled up with the globules "of fire contained therein." *Homberg. ibid.*

fun, where the cold is always extremely pinching; and this even under the Equator; mountains being there found perpetually cover'd with fnow, tho' there can be no want of fire.

So, a large burning-glafs, in a place where the fun does not fhine, or when the fun is cover'd with a cloud, has no effect; the fmalleft warmth cannot be felt in its *focus*: But the moment he emerges, a piece of metal will be feen to melt.

*A little fire may burn vehemently.*

2°, Fire may be in exceeding fmall quantity, and yet burn with great violence: Thus, fpirit of wine, when fet on fire, does not burn the hands; and, tho' poured on a piece of red-hot iron, does not take fire; fo that the fire therein fhould not appear very great. Yet, if, in burning, it meet with fome other harder body, whofe particles it is capable of agitating by the attrition of its own, it will yield a fierce flame, capable of burning a firmer body than the hand.

*The inftruments of heat and burning.*

From this it appears, that the rotation of heterogeneous particles agitated by the fire, has more effect in refpect of heat, than the action of the fire itfelf. Nor is the mechanical reafon hereof far to feek; for the particles of fire being fuppofed all equal, and fpherical, muft of themfelves be harmlefs; but if they carry along with them certain *fpicula*, or other pointed bodies, they then become capable of doing much harm.

Hence, tho' the flame of a piece of wood may give a fenfe of heat, and burn things applied to it; it does not neceffarily follow, that there is any pure fire therein: fo that the diftinction between pure and common fire, is of abfolute neceffity.

*Elementary fire.*

*Elementary fire* is that we find collected in burning mirrours; as that of M. *Villette*. This fire needs no *pabulum* or fuel to fuftain it, yields no fmoke, emits no flame, nor yields any afhes.

*Vulgar fire.*

*Vulgar, or common fire*, is that which we every where fee excited in oil, wood, *&c.* How to diftinguifh between thefe, will appear from what follows.

Pure fire is found in two different manners; either as it exifts every where, and diffufed equally in all places; or, as it exifts in certain bodies, which it makes no great alteration in.

*Elementary fire equally in all places.*

That fire fhould exift in the fame quantity, in all places, will feem a ftrange paradox: and yet the thing is demonftrable from innumerable experiments.

The *Cartefians*, as *Mariotte*, *Perrault*, *&c.* hold, that in a perfect *vacuum*, *i. e.* a fpace out of which all the air has been exhaufted, there is yet a large ftock of fire; as fuppofing an abfolute *vacuum* impoffible. Now, the moft perfect *vacuum* we can arrive at, is that of M. *Huygens*'s contrivance, which is as follows: Heat a quantity of the pureft mercury to the degree of boiling-water, and pour it into a hot tube of about forty inches long: when the tube is filled, apply a finger on the orifice thereof, and thus invert it, in a bafon full of mercury. The mercury will now be fufpended in the tube to the whole height; till giving it a little fhake, it will fink to the height of about twenty-nine inches; and thus leave a perfect vacuity of eleven

eleven inches. Yet here, the philoſophers abovementioned deny there is any *vacuum*; urging, that ſo much the more fire is now enter'd into the ſpace, as before there was of other matter: But this is contrary to experience; at leaſt, the fire there contained, is no hotter than the mercury itſelf. For a drop or two of water being ſprinkled in a froſty ſeaſon, both on the upper part of the tube ſuppoſed to be full of fire, and onthe lower full of mercury; they will freeze alike in each place. So that there is no more pure fire in the moſt perfect *vacuum*, than in any other place.

But fire, we have ſaid, is found in all bodies *. To prove which, ſet gold againſt the *vacuum* juſt mentioned; and this gold, tho' the moſt ponderous of all bodies, will not contain more fire than is in *Huygens*'s *vacuum*; as appears from the thermometer. *In all bodies.*

But the fire in gold, when ready to fuſe, is pure fire; for a maſs of this metal, once heated red-hot, will retain this fire perfectly for three days: Nay, the prince of *Mirandola*, and others, have kept gold ignited for two months, without any diminution of weight. See what has already been obſerved on this head, *p. 63, 64*.

Now, this fire, of itſelf, always lies conceal'd; nay, where it is in the greateſt quantity, it may yet be perfectly undiſcoverable: as is evident in the torrid zone; where, notwithſtanding the great abundance of fire, the ſnow in many places never melts. *Elementary fire always latent.*

It will ſcarce appear credible, that there ſhould be the utmoſt degree of fire where no flame appears, nor any light is ſeen: and yet 'tis certain that the ſun is placed in the centre of the ſyſtem, and that he emits rays all around him, as far as the ſphere of *Saturn*; and that the light reflected from *Saturn*, comes originally from the ſun: And we all know, that when the conical ſhadow of our earth occaſions night, the rays in their paſſage to *Saturn*, muſt travel through thoſe immenſe ſpaces of the heavens, which yet we find involved in darkneſs. We ſee the ſpace, but the rays we ſee nothing of, till they have perform'd their journey, and are ſome of them diſpatched again to us.

* Bodies of any kind being violently moved againſt one another, will grow hot by ſuch friction, and this to a conſiderable degree; which ſhews, that all bodies have fire in them. For fire may be put in motion, and ſeparated from a body, by ſuch rubbing; but can never be generated that way. *s'Graveſand Phyſic. Element.*

Quick-ſilver is allow'd the coldeſt of all fluids; inſomuch that "many," ſays Mr. *Boyle*, "deny that it will produce "any heat by its immediate action on "any other body, and particularly on "gold: but ſeveral trials have aſſured "me, that a particular mercury may, by "preparation, be enabled ſuddenly to "inſinuate itſelf into the body of gold, "whether calcined or crude, and be"come manifeſtly hot with it, in leſs "than two or three minutes." *Boyle Mech. Prod. of Heat.*

"That quick-ſilver contains fire, is e"vident hence, that if you ſhake it a"bout in an exhauſted glaſs, it will ap"pear all luminous. But for this experi"ment, 'tis neceſſary the mercury be "very pure and defecate: if it have no "tin mix'd in it, you may purge it with "boiling-hot vinegar." *s'Graveſand ibid.*

*Fire discover'd,* This fire, in it ſelf thus perfectly latent, may diſcover it ſelf to be preſent by five effects.

*By the rarefaction of bodies.* 1°, By *rarefying bodies*, and *particularly air* : For we have already obſerved, that the fluidity of all liquors depends wholly on fire ; and conſequently all rarefaction. There is no fire, but what rarefies air : and all oils, waters, ſpirits, and, in one word, all fluids are rarefied by the ſame cauſe. Nay, and ſolids themſelves rarefy by fire : Thus a bar of iron, by the mere warmth * of a puff of breath, or the application of a hand, ſhall be ſenſibly extended.

*By light.* 2°, Fire ſhews it ſelf to be preſent by *light* : for wherever there is light, there is fire. The ſenſation of light is produced when the particles of fire, directed by the action of the ſun, reach the eye in right lines. Without this circumſtance of determination, fire would never be viſible ; as is evident from a darken'd chamber, wherein the rays received in at an aperture of the wall, and proceeding along the chamber, are not at all ſeen, till being reflected from the wall, they return and ſtrike the eye in right lines. Nothing, therefore, ſhines without fire ; but neither does fire ſhine of it ſelf, unleſs it flow from the lucid body in right lines †.

*By colour.* 3°, Fire diſcovers it ſelf by *colour* : for all colour depends on light ; and light, we have obſerv'd, depends on fire. This, *Virgil* alludes to in that beautiful verſe, where he ſays,

——*Rebus nox abſtulit atra colores.*

And the ſame is proved by Sir *Iſ. Newton*, in his optics, by a great number of experiments. That author ſhews, that a ſingle ray of light, which had always been taken for a ſimple body, becomes divided, by reflection, into a great number of rays, of divers colours ; and this in a conſtant law : and that 'tis only as bodies are diſpoſed to reflect this or that ſort of colour'd rays more than others, that they appear of this or that colour : without ſuch colour in the rays of fire, all bodies would remain inviſible ; ſo that all we ſee in bodies,

* Thus *s'Graveſand* : " All bodies are " dilated by the action of fire ; but the " degree of ſuch dilatation, ſeems rather " to depend on the motion, than on the " quantity of fire. For bodies are expanded by rubbing, as well as the ap" plication of fire externally. *Element. Phyſ.*
" From this expanſion it follows, that " the conſtituent particles of bodies, ac" quire a repelling force by the action of " fire ; in virtue whereof, they endeavour " to recede from each other, with a ten" dency contrary to that of attraction. " While this laſt force remains ſtronger " than the other, the particles cohere " more or leſs, according to the leſs or " greater degree of heat : When the re" pelling force is almoſt equal to the at" traction, the particles before firmly " join'd, ſcarce cohere, yield to the ſmal" leſt impreſſion, and are eaſily moved a" mong each other : And thus it is, that " a ſolid becomes a fluid by heat. The " effect may be ſo increaſed in ſome bodies, " as that the attracting force ſhall be over" come by the repelling force, in which " caſe the particles fly from each other : " and thus it is that heat volatilizes bo" dies. *Id. ib.*

† Thus *s'Graveſand* : Fire entering the eye in right lines, gives a motion to the optic fibres at the bottom of the eye, and thus excites the idea of light. That light can have no other motion but a rectilinear one, appears from the ſtopping or intercepting it by a body directly interpoſed between the luminary and the eye ; and hence a body is ſaid to be *lucid* or *luminous*, when it gives fire a motion in right lines. *Ubi ſupra.*

bodies, is fire alone: which is a paradox first demonstrated by Sir *If. Newton.* The truth is, the different colours of objects arise merely from the different reception of the rays of light, the different divisions they make thereof, and the different parts they retain and repel ||.

4°, It discovers it self by *heat:* fire is never without both heat, and light; tho' it's possible for those to be in so small a degree, as not to be sensible. Thus, by the attrition of mercury in a glass vessel, and a dark place, it presently emits light; but if this be done in a place illumined, no light is seen; and yet there is the same light on the part of the luminary, as in the former case. So if you grind a little mercury and fine glass together, the glass will presently grow both hot and luminous; and the same obtains in sugar, and other bodies, which when at rest emit no light, but by rubbing, readily do: and yet such bodies are not hot; for if you shake a little mercury in a clean glass vessel, it shall shine, tho' it does not afford any indication of heat when applied to the thermometer: so that a sensible light may arise, before there be any sensible heat. On the contrary, if you take two pieces of iron, and rub one against the other in a dry air, they will grow extremely hot e'er they shine at all; but with further friction will shine sensibly enough. So that light does not constantly either precede or follow heat; but both are present at the same time, tho' not both alike sensibly. *By heat.*

And hence fire is divided into *lucid* and *not lucid*; to shine, not being any native, essential property of fire; but depending on the various determinations thereof. *Light or shining not essential to fire.*

Thus if you hang up several different colour'd clothes, in a dark place; some white, others red, and others black; and place your self at a little distance: you will perceive nothing at all where the black are; where the white are, there will something appear; so also where the red are, tho' less than where the white. Not that there is more fire in one than another; but one reflects more or fewer rays than another; so that the cir-

|| Natural bodies only become of different colours, as surfaces are disposed to reflect differently colour'd rays; and a body appears of the colour which arises from the mixture of the rays reflected by it. Thus placing two bodies, *e. gr.* a red and a blue one in the dark, where neither of 'em is visible; and enlightning 'em successively by rays transmitted thro' a prism; they will then be seen, and each of the sorts of colour'd rays, will be reflected from each: But the red rays will be much the most copiously reflected from the red body, and the blue from the blue. And enlightning 'em both with only one sort of rays, *e. gr.* red ones; the red object will be very vivid, and the blue scarce visible.

To determine the precise constitution of the surface of bodies, whereon their colour depends; it is to be observed that the smallest particles of all bodies are found to be transparent; and that they are separated by a medium of a different density from the particles themselves: and hence, in the surface of every colour'd body, we may conceive innumerable, small thin lamellæ, or plates. But it is demonstrated of such plates, and consequently of the surfaces of bodies, that their colour depends on the thickness, and density of the parts or plates in the surface, between the pores thereof; that the colour is so much the more vivid and homogeneous, as the plates or parts are thinner; and that, *cæteris paribus*, the said parts are the thickest, when red; and thinnest, when violet.

cumstances

cumſtances of light do not depend on fire, ſo much as on the ſurface of the body that reflects it.

*Heat or warming not eſſential to fire.*

Lucid fire, again, is of two kinds, *viz.* that which *warms*; as red-hot iron: and that which does *not warm*, as that in rotten fiſhes; the oils whereof being attenuated enough to rub againſt one another, yield light, but without any heat that the barometer takes cognizance of. But heat is our own ſenſation; nor is it to be deem'd a juſt meaſure of the quantity of fire:

*Heat no ſtandard of the degree of fire.*

Thus, a man coming out of a hot bath, even into a moderately warm air, will ſeem as if he were come into an exceſſively cold place; and another entering a warm room, in a cold winter's day, will at firſt fancy himſelf in a ſtove. This ſhews, that the ſenſe of heat does by no means determine the exact degree of fire; as being always relative to our bodies: And hence, ſome perſons ſcarce perceive the ſevereſt cold; and others, on the contrary, the moſt ſultry heat: ſo that the degree of heat depends on a compariſon of the perſon who perceives it *.

*Fire diſcover'd by burning.*

5°, Fire diſcovers it ſelf by *burning* †.

From what has been ſaid, we may infer a very remarkable property of fire, and which every body will eſteem as a paradox, *viz. that fire is preſent every where.* Pure, or elementary fire, we aſſert, is equally preſent in all places; nor is there any point of ſpace, or any body, wherein there is more found than in any other.

*Further experiments and conſiderations to prove fire in all places and all bodies, alike.*

For we have already ſhewn, that there is the ſame degree of fire in the moſt perfect vacuum in nature, as in the moſt ſolid body; in mercury, as in oil of vitriol; and that it is equally preſent in ice or ſnow, as the pureſt ſpirit of wine: and hence we argue, that there is a good quantity of fire even in the coldeſt places, and the coldeſt bodies; which is further confirmed from the following experiment.

Take two large iron planes, and rub 'em briskly againſt each other, in *Iceland*, which is only 12 degrees ſhort of the *North Pole*, in the moſt froſty ſeaſon, and at midnight; and they will grow warm, glow, ſhine, and heat to ſuch a pitch, as not only to rarefy the ſpirit in the thermometer, but even to ignite, and at laſt to fuſe. Now, the fire here found, is either created *de novo*, or it was there before: But its creation, no body will aſſert; and accordingly unleſs a proper fuel be furniſhed it, it is ſoon diſſipated again;

* A body is only ſenſibly hot, when the degree of its heat exceeds that of our organs of ſenſe; ſo that there may be a lucid body, without any ſenſible heat; and conſequently, as heat is only a ſenſible quality, without any heat at all.

Heat, in the hot body, ſays *Graveſande*, is an agitation of the parts of the body, made by means of the fire contained in it; by ſuch agitation a motion is produced in our bodies, which excites the idea of heat in our mind: ſo that heat in reſpect of us is nothing but that idea; and in the hot body, nothing but motion. If ſuch motion expel the fire, in right lines, it gives us the idea of light; if in a various and irregular motion, only heat.

† The minute parts whereof a body conſiſts, being vehemently agitated by attrition, the application of external fire, or the like cauſe; the fire contained therein is ſeparated from thoſe particles, and turn'd looſe in the body: where, by the attraction between the particles of the fire and of the body, a mutual action ariſes; by which ſome parts are torn off from the body, and carried away by the motion of the fire. *s'Graveſand, ubi ſupra.*

not

not annihilated: Consequently it pre-existed: and that it is true fire, appears from its rarefying the spirit in the thermometer. Fire, therefore, which before existed, in such a diffused and dispersed state as not to be sensible; being now collected by the attrition, becomes perceivable by the senses.

So if two bodies be so briskly moved against each other, as that no other ambient matter, but fire, on account of its wonderful subtility, can follow 'em with equal pace; they must necessarily collect the fire, before vague and dispersed. And thus it is that the wheels of chariots, and other vehicles, by their excessive velocity take fire; and that balls exploded in the night-time out of great guns, grow hot in their passage thro' the air, so, as sometimes to appear ignited *.

The experiment abovementioned, with iron planes, does not succeed so well in summer, as winter: the reason is owing to the diminution of elasticity in bodies, by heat; whereas cold augments it. Hence it is, that M. *Villette*'s mirror burns more forcibly in winter than in summer; nay, and that to have it burn with its utmost vehemence, the hind part of the mirror is to be very cold.

I have heard it alledg'd, that the iron planes, in the experiment above-recited, are themselves converted by the friction into fire. But is this possible, and yet the iron remain without the loss either of bulk or weight, and return, in a few minutes, into its primitive form? But, that fire is equally diffused every where, will appear from another inconteStable experiment. The utmost effect, the greatest fire is capable of producing, is, in a moment's time to turn a flint into glass; which effect is peculiar to M. *Villette*'s mirrour||, and is what M. *Tschirnhausen*'s burning-glass will not perform: a lime-stone, which would endure the utmost effort of the hottest furnace for many months, being exposed to the mirror, instantly passes, with a little hiss, into glass. Now this we may lay down as the ultimate degree of fire known among us: and yet we assert, that this same degree of fire is found every where. For if, even in *Iceland*, in the middle of winter, and at midnight, a steel and flint be but struck against each other, with a piece of paper underneath; a spark of fire will fly off, which falling on the paper, will be found, by the microscope, to be a perfect globule of

* "A bullet shot out of a good wind-" gun, against a metalline plate, Mr. *Boyle* "found would be flatted almost into the "figure of an hemisphere. The same "author going to take up the bullet, "found it too hot to be, without pain, "held betwixt the fingers. *Effects of Lang. Mot.*

|| "M. *Villette*'s burning concave is 47 "inches wide, and ground to a sphere of "such a radius, that its focus is about 38 "inches from the vertex of the glass. The "metal of it is a mixture of copper, tin "and tin-glass. This concave melted "iron-ore in 24″; began to calcine talc "in 40″, and, as M. *Villette* said, would "calcine *asbestos*. It melted a sixpence in "7″$\frac{1}{2}$, and a $\frac{1}{2}$ penny in 16″. It turned "an emerald into a substance like a tur-"quoise-stone; and diminished a diamond, "that weigh'd 4 grains by $\frac{7}{8}$, of its weight. *Philos. Trans.* N°. 360

glass.

glaſs †. Whence it follows, that there is the ſame degree of fire in the cold regions of *Iceland*, as in *Villette*'s burning-glaſs; the ſame effect being produced in both.

Hence, as the ſame experiment ſucceeds alike in all places, and at all times; there is no doubt, but that fire is always found in all parts of ſpace, and in all bodies: equally ſpread on the utmoſt top of the higheſt mountain, as in the ſubject valley, or in the deepeſt cavern under ground; in every climate, and at every ſeaſon.

We add, that the ſame quantity of fire is found in all bodies, how different ſoever in texture, conſiſtence, ſolidity, &c. Thus applying ſeveral bodies, *e. gr.* alcohol of wine, quickſilver, oil, iron, gold, &c. to ſo many thermometers for a whole night, the ſpirit was found, next morning, at the ſame height in 'em all.

*Fire only appears when collected.*

Hence we draw an inference of the laſt importance, *viz.* that *fire only becomes apparent, by being collected*, or gather'd nearer together. So that there is no exciting, producing or making of fire, or even putting it in motion; but the whole of what we do, is to collect what was before diſperſed, and bring it into a narrower compaſs ||.

Fire,

† "By an almoſt momentary percuſſion, with no great force, the parts even of a vegetable may not be only intenſely heated, but brought to actual fire; as we have tried by ſtriking a good cane with a ſteel, or the back of a knife; for upon this colliſion, it would yield ſparks like flint. So likewiſe by ſcraping a good loaf of ſugar, with a knife, numerous ſparks will be produced; but upon the colliſion of a flint and ſteel, not only fire, but even vitrification, which the chemiſts eſteem the ultimate action of fire, is inſtantaneouſly produced: for the ſparks which here fly off, are uſually real and permanent parcels of ſtone, vitrified by the vehemence of the motion. And that this vitrification may be of the ſtone it ſelf, tho' ſteel is of a far more fuſible nature, I am induced to think, becauſe flints will, by colliſion, ſtrike fire with one another. The like alſo may be done with rock-cryſtal, and even with diamonds, on the mill whereby they are cut; tho' fire is not allowed to fuſe them. *Boyle, Effects of languid Mot.*

|| Hear what the philoſophers on the other ſide the queſtion have to ſay. "That heat is mechanically producible, appears probable from a conſideration of its nature; which ſeems principally to conſiſt in that mechanical property of matter call'd *motion*; but which is here ſubject to three conditions, or modifications.

"*Firſt*, the agitation of the parts of the body muſt be *vehement*; for this diſtinguiſhes the bodies ſaid to be hot, from thoſe which are barely fluid: thus the particles of water, in its natural ſtate, move ſo calmly, that we do not feel it at all warm, tho' it could not be a liquor, unleſs they were in a reſtleſs motion; but when water comes to be actually hot, the motion manifeſtly, and proportionably appears vehement, ſince it does not only ſtrike our organs of feeling briskly, but ordinarily produces numerous very ſmall bubbles, melts coagulated oil caſt upon it, and affords vapours, which by their agitation aſcend into the air. And if the degree of heat be ſuch as to make the water boil, then the agitation becomes more manifeſt, by the confuſed motions, waves, noiſe, bubbles, and other obvious effects excited therein. Thus in a heated iron, the vehement agitation of parts may be eaſily inferr'd from motion, and the hiſſing noiſe it makes with the drops of water that fall upon it.

"But

Fire, then, is a body *ſui generis*, not creatable, or producible *de novo*, by any natural or artificial means. Its quantity is fix'd, and invariable; and the utmoſt that we can do with it, and which has led us to think it producible, is, that of inſenſible, it may be render'd ſenſible; where before there was

" But tho' the agitation be various as " well as vehement, there is yet a third " condition required to make a body hot: " which is, that the agitated particles, or " at leaſt the greateſt number of them, be " ſo *minute*, as to be ſingly *inſenſible*. Were " an heap of ſand to be vehemently agi- " tated by a whirlwind, the bulk of the " corpuſcles would keep their agitation " from being properly heat; tho' by their " numerous ſtrokes upon a man's face, " and the briſk commotion of the ſpirits, " and their ſmall particles, which may " thence enſue, they may perhaps pro- " duce that quality.

" The *ſecond* condition is, that the de- " termination be very various, and tend " all manner of ways. This variety of de- " terminations appears to be in hot bodies, " both by ſome of the inſtances already " mentioned, and eſpecially that of flame, " which is a body; by the dilatation " of metals when melted; and by the " operations of heat, exerciſed by hot " bodies upon others, in what poſture or " ſituation ſoever the body to be heated " thereby is applied to them: thus a coal " thoroughly kindled, will appear on all " ſides red, and melt wax, and kindle " brimſtone, whether the body be applied " to the upper, the lower, or to any other " part of it."

Hence if we duly attend to this notion of the nature of heat, 'tis eaſy to diſcern how it may be mechanically produced ſeveral ways: for, except in ſome few anomalous caſes, by whatever means the inſenſible parts of a body can be put into a very confuſed and vehement agitation, heat will be introduced into that body. And as there are ſeveral agents, and operations, by which the heating motion may be excited; ſo there muſt be ſeveral mechanical ways of producing heat. Various experiments may be reduced to almoſt each of theſe heads; chance it ſelf having, in the laboratories of chemiſts, afforded ſeveral phenomena, referable thereto. *Boyle, Mechan. Orig. of Heat.*

Conſiſtent with this, is the ſyſtem of the Lord *Bacon*: that noble author is ſo far from imagining any particular body neceſſary to exhibit the phenomena and effects of fire, that he undertakes to aſſign preciſely the mechanical cauſe of heat, and point out the means neceſſary to generate it in any body, without ſuppoſing any pre-exiſtent fire at all.

From a particular enumeration of the ſeveral phenomena and effects of heat, he deduces, 1°, That heat is motion: not, that motion generates heat, or heat motion; tho' in many caſes, this be true: but that the very thing heat is very motion, and nothing elſe. But this motion he ſhews, has ſeveral peculiar circumſtances which conſtitute it heat. As, 2°, That it is an *expanſive motion*, whereby a body endeavours to dilate or ſtretch into a larger dimenſion, than it had before. 3°, That this expanſive motion is directed *towards the circumference*; and at the ſame time *upwards*; which appears hence, that an iron rod being erected in the fire, will burn the hand that holds it, much ſooner than if put in laterally. 4°, That this expanſive motion is not equable, and of the whole, but only of *the ſmaller particles* of the body; as appears from the alternate trepidation of the particles of hot liquors, ignited iron, &c. Laſtly, that this motion is very *rapid*.

Hence he defines heat " an expanſive " undulatory motion in the minute parti- " cles of a body, whereby they tend with " ſome rapidity, towards the circumfe- " rence, and at the ſame time incline a " little upwards." Hence, again, he adds, that if in any natural body, you can excite a motion whereby it ſhall expand or dilate it ſelf; and can ſo repreſs and direct this motion upon it ſelf, as that the dilatation

was no ſign of it, it may be made manifeſt. But this, as already intimated, is only effected by determining and collecting it; by bringing it out of a larger ſpace into a leſs, and driving or directing it upon this body or that. For as to the fire it ſelf, we ſhall hereafter ſhew it a moſt minute, ſolid, ſimple, penetrative body: and conſequently far out of the reach of our imitation.

Sir *Iſ. Newton*, indeed, ſuggeſts that groſs bodies and light are convertible into one another: fire, he conceives, to be no more than the minute corpuſcles of ſome fix'd body, violently agitated; and thinks the matter of any body capable of becoming fire, by a ſufficient attrition. But that a body, which before was not fire, ſhould by attrition become real fire, and at once be inveſted with ſo many ſingular properties, which no other body has, *v. gr.* light, colour, different refrangibility, *&c.* of its ſides; appears to us inconceivable; and requires further proof, which that illuſtrious author does not pretend to give. The only argument he produces, is the conforma-

ſhall not proceed uniformly, but obtain in ſome parts, and be check'd in others; you will generate heat. *De forma Calidi.*

This ſyſtem is further ſupported by Sir *Iſ. Newton*, who does not conceive fire as any particular ſpecies of body, originally endued with ſuch and ſuch properties. "Fire, according to him, is only a body much ignited, *i. e.* heated hot, as to emit light copiouſly: what elſe, ſays he, is a red-hot iron than fire? and what elſe is a burning coal than red-hot wood? or flame it ſelf than red-hot ſmoak? 'Tis certain, that flame is only the volatile part of the fuel heated red-hot, *i. e.* ſo hot as to ſhine: and hence only ſuch bodies as are volatile, *i. e.* ſuch as emit a copious fume, will flame; nor will they flame longer than they have fume to burn. In diſtilling hot ſpirits, if the head of the ſtill be taken off, the aſcending vapours will catch fire from a candle, and turn into flame. So ſeveral bodies much heated by motion, attrition, fermentation, or the like, will emit lucid fumes, which, if they be copious enough, and the heat ſufficiently great, will be flame; and the reaſon why fuſed metals do not flame, is the ſmallneſs of their fume; for that ſpelter, which fumes more copiouſly, does likewiſe flame. Add, that all flaming bodies, as oil, tallow, wax, wood, pitch, ſulphur, *&c.* by flaming waſte, and vaniſh into burning ſmoak. *Opticks.*

"And do not all fix'd bodies, when heated beyond a certain degree, emit light, and ſhine; and is not this emiſſion perform'd by the vibrating motion of their parts? and do not all fix'd bodies, when heated beyond a certain degree, emit light and ſhine? and is not this emiſſion perform'd by the vibrating motions of their parts? and do not all bodies which abound with terreſtrial, and ſulphurous parts, emit light as often as thoſe parts are ſufficiently agitated, whether that agitation be made by external fire, or by friction, or percuſſion, or putrefaction, or any other cauſe? Thus ſea-water in a ſtorm, quickſilver agitated *in vacuo*, the back of a cat, or neck of a horſe obliquely rubb'd in a dark place, wood, fleſh, and fiſh while they putrefy, vapours from putrefying waters, uſually call'd *ignes fatui*, ſtacks of moiſt hay or corn, glow-worms, amber and diamonds by rubbing, ſcrapings of ſteel, ſtruck off with a flint, *&c.* *Ibid.*

"——Are not groſs bodies and light convertible into one another; and may not bodies receive much of their activity from the particles of light, which enter their compoſition? I know of no body leſs apt to ſhine than water, and yet water by frequent diſtillations changes into fix'd earth; which by a ſufficient heat may be brought to ſhine like other bodies. *Ibid.*

bleneſs

bleneſs of ſuch converſion (of light into bodies, and bodies into light) to the courſe of nature, which ſeems delighted with ſuch transformations.

We have now proved the equable diſtribution of fire in all places; whence it ſhould follow, that there is the ſame degree thereof every where: which would really be the caſe, were it not that fire happens, by one means or other, to be more collected in one place than another. The manner of this I conceive to be as follows: ſuppoſe a certain quantity of fire, *e. gr.* 100 particles, contained in the ſpace of a cubic foot, and equally diffuſed throughout the ſame. Here, each aſſignable point of ſpace will have that degree of fire, which ſuch an allotment will afford, *i. e.* the effect of the fire will be proportional to its quantity. If, now, thoſe 100 particles before diffuſed thro' ſuch ſpace, by any means be driven into one ſide of that cubic foot; or if they be collected into the ſpace of one inch: then, that ſame fire, thus brought nearer, will have much greater effects, *i. e.* will become more ſenſible; and that in the inverſe ratio of the ſpace it poſſeſſes.

*Whence the difference of fire in different places.*

This collecting of fire is alſo confirm'd by experiments; which make it appear, that if the ſtock of fire in any place be larger than ordinary, the neighbouring places have ſo much the leſs; and that to freeze water the ſooneſt poſſible, a huge fire ſhould be made; after which, placing the water juſt without the door, it will ſhoot into ice, without delay. Thus if you build a very large fire in ſome ſpacious place; the neighbouring places will be found to have ſo much the leſs, as the fire burns the more ſtrongly. And hence it is, that at ſome times and ſeaſons, we feel ſuch a vehement heat in our part of the globe, and at other times ſcarce any; a greater, ſometimes, and ſometimes a leſs adventitious ſtock being ſent us from other parts. Hence it alſo is, that the windows of ſtoves, and hot houſes, are ſo often cover'd with ice.

Some may here object thoſe experiments of Sir *Iſ. Newton*, whereby he endeavours to ſhew that fire may poſſibly be more attracted by ſome bodies than others: but, with the freedom that becomes a philoſopher, I here anſwer, that there is no body known, which being placed in a temperate air, has more fire than any other *. Indeed, moſt people imagine, that feathers, *e. gr.* are warmer than mercury; but the thermometer may convince 'em of their miſtake. Thus petrol, ſpirit of wine, *&c.* are in reality no hotter than water; and the like may be ſaid of all other bodies: ſo that we doubt very much whether there be any ſuch thing as bodies that properly attract fire; or that are, with reſpect to fire, what a magnet is to iron.

All other bodies, we allow, have their proper magnets or attractives; as air, for inſtance, waters, earths, *&c.* but for fire, we know of none:

*No attractive of fire.*

* *Quouſque autem hoc aſſertum cum iis quæ de calce viva, phoſphoro, corporibus nigris, cæteriſque, quæ ignem quodammodo haurire, figere, detinere videntur; a* Newtono, Boyleo, Lemeræo, *atque ipſo etiam* Boerhaavio, *poſtmodum notata, conſiſtat: auctor ipſus videat.*

none *. And however ſomething might be inferr'd to the contrary, from what *Roemer*, and *Newton* have ſhewn of the velocity of light, and the refraction of its rays; yet, thoſe authors hold attraction to be always in the ratio of the denſity of bodies, whereas we have demonſtrated that the denſeſt of all bodies, gold, has not more fire than the moſt perfect vacuum.

And this gives us occaſion to adore the infinite wiſdom of the great creator. For had there been any thing that attracted fire; it would have become a perpetual furnace: and how unhappy muſt the condition of man have been under ſuch circumſtances?

*Two ſources of fire.*

However, the equable diffuſion, *&c.* of fire, thro' all the mundane ſpace, does not hinder, but that to our ſenſes it appears very unequally in different places; and hence we have two vulgarly reputed ſources, or funds of fire, *viz.* in the *ſun*, and the *centre* of the earth.

*The ſun.*

For the firſt, we have the concurrent opinions of the philoſophers of all ages; except one, who held the ſun to be cold.

*The centre of the earth.*

As to the central fire, tho' our obſervations do not go ſo far; yet this is manifeſt, that there is an ample proportion of fire under ground; and even that fire appears much more abundant there than on the ſurface: ſo that at leaſt a *ſubterraneous* fire muſt be granted.

*Subterraneous parts the hotter the deeper they are.*

Thus, they who dig mines, wells, *&c.* conſtantly obſerve, that while they are yet but a little below the ſurface, they find it a little cool; as they proceed lower, it grows much colder, as being then beyond the reach of the ſun's heat; inſomuch that water will freeze almoſt inſtanteouſly, and hence the uſe of ice-houſes, *&c.* But a little lower, *viz.* about 40 or 50 foot deep, it begins to grow warmer: ſo that no ice can bear it; and then the deeper they go, ſtill the greater the heat: till at length it endangers the ſtoppage of reſpiration, and puts out their candles †. If they venture yet further with

* "Sir *Iſ. Newton*, however, ſhews, "from a great variety of particular experiments, that bodies do act on light, at "a diſtance; and by their action inflect "and bend its rays; which action, *cæteris paribus*, is ſtrongeſt at the leaſt diſtance. "He adds, that in paſſing by the edges "and ſides of bodies, the rays bend ſeveral times backwards and forwards with "a motion like that of an Eel: and that "the rays which are either refracted or "reflected, begin to be bent before they "arrive at the reflecting or refracting "bodies. *Optice.*

"As attraction is ſtronger in ſmall magnets than great ones, in proportion to "their bulk; and gravity is greater, on "the ſurfaces of ſmall planets than on "thoſe of great ones; and ſmall bodies "are agitated more by electric attraction "than great ones: So the ſmallneſs of the "rays of light may contribute much to "the force of the agent whereby they are "inflected, *&c. Id. ibid.*

† *Morinus*, a *French* author, who had the curioſity to deſcend himſelf into the mines of *Hungary*, ſome of which are 3 or 400 fathom deep, relates, that after he had deſcended about 100 fathom, he came into a very warm region of the earth, which laſted to the bottom of the mine; being ſo hot both in winter and ſummer, that the labourers uſually work without their clothes: he adds, that he himſelf was ſcarce able to bear the heat. He was further told by the overſeers, that 'twas univerſal; the lower they deſcend beyond 100 fathom, the hotter it ſtill growing.

Mr. *Boyle*, however, having been to the

with a lighted candle, the place ſhall be immediatdly found full of flame: as once happen'd in the coal-pits in *Scotland*; where a hardy digger deſcending to an unuſual depth, with a light in his hand; the fumes, which were there found very copious, caught fire thereby, (they being no other than oil or ſulphur greatly rarefied and volatilized by heat) and burnt the whole mountain down.

It ſeems, therefore, as if nature had lodg'd another ſun in the centre, to contribute, on its part, to the giving of motion to bodies; and to the promoting of generation, nutrition, vegetation, germination, &c. of animals, vegetables, and foſſils; and that all productions, under ground, in particular, as of metals, ſalts, &c. are wholly owing thereto. *Central ſun.*

How this ſubterraneous ſun aroſe, may admit of ſome doubt; whether it were form'd there from the beginning, like the ſun in the firmament; or gradually produced by a ſecondary collection of vague fire into this place? What pleads in favour of the former opinion, are volcanoes, or burning mountains, which appear to have exiſted from the firſt ages: for *Ætna's* flames are ſpoke of among the antient poets, as even then of great antiquity. And ſuch mountains are found in the coldeſt regions, *viz. Nova Zembla*, and *Iceland*; as well as the hotteſt, as *Borneo*, &c. † *How form'd: Whether ab origine.*

In behalf of the other opinion it is urg'd, that ſuch ſource of fire might have aroſe there in time, on the principle of gravity. For tho' fire be by nature equally diſſeminated every where; yet, as we ſhew it to be a body, and inveſted with the other properties of body; it muſt have weight; and in conſequence thereof muſt have a tendency toward the centre. Hence it muſt be accumulated deep under ground; and the more ſo, the nearer the centre, which may be eſteem'd the common ſeat or receptacle it all tends to. This may receive ſome confirmation hence, that the central ſpace is allowed to be poſſeſſed by the heavieſt and moſt ſolid bodies; but we know of nothing to enter the pores of thoſe bodies, and make 'em more ſolid than others, except fire. *Or by ſecondary cauſes.*

the bottom of ſome mines himſelf, ſuſpects, that this degree of heat, obſerved in the *Hungarian* Mines, might in great part proceed from the peculiar nature of the place, or of the minerals generated there; and not wholly from their depth. Very credible eye-witneſſes have aſſured him, that in ſome parts of *England*, they dig up large quantities of a kind of mineral, ſuppoſed to be vitriolic, which, by the bare addition of common water, will grow ſo hot as almoſt to take fire: ſo that the *Hungarian* mines being deep, and not deſtitute of water, it may be ſuſpected, that either this fluid, or ſome peculiar mineral ſpirit, or juice, may with the mineral produce a warm ſteam, which for want of ſufficient vent, in thoſe cloſe places, yields a conſiderable heat. *Hiſt. of Cold.*

† "It cannot be reaſonably pretended, "that the ſubterraneal heat proceeds "from the rays of the ſun; ſince they heat "not the earth above 6 or 7 feet deep, "even in the ſouthern countries. And if "the lower part of the earth were, of its "own nature, cold, and received the "heat it affords, only from the ſun and "ſtars; the deeper men deſcend therein, "the leſs degree of heat and ſteams they "would meet with. *Id. ibid.*

Upon

Upon the whole, in the firſt view, there ſhould be two great fires, an upper or *ſolar*, and a lower or *central* one; in all reſpects alike, and the ſame with each other; according to the dogma of *Triſmegiſtus* above recited. On the ſecond view, the central and ſubterraneous fire is not original and elementary, but determined and collected fire; ſuch as we have it on various occaſions about the ſurface. It may be added, that the denying vent or paſſage to this ſubterraneous fire, appears to be the cauſe of earthquakes; thoſe uſually ariſing upon a volcano's appearing to be ſtopp'd up, or ceaſing its eructations; and going off again, upon its opening, or burning a-freſh.

## *Two ways of Collecting Fire.*

FIre may be collected in two manners, 1°, By a luminary determining its rays into a paralleliſm; and 2°, By attrition.

*The ſun collects fire.* 1°, Fire, as already obſerv'd, is collected, when by any means a quantity thereof is driven into a leſſer compaſs; it being part of the character of fire, that it ſpreads it ſelf equally; ſo that if left to it ſelf, would be found no more here than there, and conſequently would be inſenſible every where. But if, by any cauſe, it be directed toward any certain part, then it diſcovers it ſelf: and ſuch a cauſe is the *ſun*, which revolving, with prodigious velocity, around his axis, directs the impervious corpuſcles of fire, every way, in parallel right lines, and determines 'em toward certain places.

*Does not emit it.* The ſun, therefore, does not produce or emit fire, but only puts it in motion in right lines, and thus collects it. And hence it is, that we perceive fire ſo long as the ſun is above the horizon; and upon his ſetting, loſe it again; by reaſon, as his action ceaſes, the fire again ſpreads it ſelf all around ||. Tho' a candle, torch, or the like, may ſometimes ſupply his abſence,

|| "The ſun, according to that excellent "chemiſt, the younger *Lemery*, ſeems to be "no other than a huge maſs, or collec-"tion of the matter of fire, or light; tho' "placed at ſuch a diſtance, as to diſable "it to act on bodies here on earth, other-"wiſe than by one of theſe two ways: "firſt, by emanations or emiſſions of his "own ſubſtance, tranſmitted hither: but "this hypotheſis being ſubject to great "difficulties, and not ſufficiently anſwer-"ing to certain phænomena, recourſe is "had to another; which ſuppoſes trains "of fire, or light, diſpoſed in all the in-"terſtices of the grand expanſe of air "and æther between the ſun and us; and "that theſe trains are made to act on ter-"reſtrial bodies, by their being vigorouſly "driven, or impell'd towards ſuch bodies, "by the immediate action of the ſun "thereon. Theſe trains in effect may be "eſteem'd as a ſort of little ſuns prolong-"ed, but always depending on the great "ſun, as the ſource of their motion, and "action on bodies: 'tis theſe that form the "rays of light; they do not, in point of "matter, differ from the ſubſtance of the "ſun himſelf; but only in this, that the ſame "thing is more copious, in one caſe than "the other. In the ſun we may ſuppoſe "the matter of light more abundant than "in the focus of our largeſt burning glaſ-"ſes: Thus, from the vehement action of "the rays of the ſun, collected in ſuch "glaſs,

ſence, by impelling, after the ſame manner, the diſperſed corpuſcles of fire, and collecting 'em into parallel rays.

Not that there is leſs fire in our hemiſphere in the night than the day-time: but light, unleſs it come to us in right lines, is it ſelf inviſible. *Fire as copious in the night as the day-time.* Thus, in a clear, ſtill night, we ſee the ſtars and planets ſhine; while the ſun, being under us, is all the while diſpenſing his light as far as the utmoſt orb of *Saturn*; and yet in all its paſſage thro' that immenſe ſpace, we ſee nothing of it, nor does any part thereof appear, but thoſe few rays reflected back in right lines to our earth. The heavens, in reality, are never more illumined, than when to us they appear wrap'd up in darkneſs; which conſideration is further confirmed from what has already been obſerved of a darken'd chamber.

Light, therefore, only acts according to parallel lines: nor does the ſun warm us, as he emits rays; but as he gathers the diſperſed fire into parallel lines, and ſo renders 'em more ſenſible: ſo that the fire is not at all the leſs, be the darkneſs ever ſo great. *Whence the ſun's warmth.* So we find the ſpirit in the thermometer ſomewhat higher in the day than the night; but if the ſun ſhine directly on it, it then riſes ſtill much higher: not that the fire is a whit increaſed, by the ſun, but becauſe it is thereby determined upon the glaſs.

Hence we deduce the following corollaries.

1°, That there may be the moſt vehement fire, without any light. *Fire without light.*

Thus, in the focus of M. *Villette*'s mirrour, where a ſword is inſtantly vitrified; we ſee no more light than in any adjacent part; ſo that if a man, diſtruſting his eyes, ſhould but apply his hand to the ſame, it would ſtraight be reduced to a coal.

Nor does iron it ſelf ſhine, till red-hot; tho' able, long before, to conſume wood, bones, &c.

2°, There may be the brigheſt light without any heat. *Light without heat.* Dr. *Hook* firſt tried the effects of a burning glaſs, and a concave mirror in the night-time. Upon oppoſing 'em to the moon, and collecting her rays, in a clear winter-night, he gather'd a light, which would immediately have blinded the beſt eye, by only looking at it. And yet by the thermometer, it appear'd that the heat was nothing more intenſe there, than in any other part of the ambient air *.

We

* glaſs, we learn what uſe the air interpoſed between the rays of light, is of, " in tempering their action, and rendering " it more ſupportable; ſince, without " ſuch medium, inſtead of warming, and " illumining, it would blind and burn us. " So that the air may be conſidered as " having ſomewhat of the ſame effect, " with reſpect to the rays of light falling " upon us, that the water in a *balneum maria* has. *Mem. de l'Acad. An.* 1713.

* If a burning mirror be held at a proper diſtance from you, in the night-time, ſo that the face be in its focus; a conſiderable warmth will be felt; which warmth does not ariſe from the common or vague external fire, but from that emitted from the body, which is collected in the cavity.

*Fire always in motion.*

We come now to shew, that this fire thus equably dispersed, is in continual motion, and never at rest †. This is easily proved: for if the fire be so diminished, as that the mercury in the thermometer sinks to 30 degrees, it will be frost; and yet, then, it is still capable of sinking to no degrees: consequently, there is such an expansion yet subsisting in the liquid.

Hence it follows, that this fluidity of the spirits requires a degree of fire, since 'tis the action thereof, by which it continues fluid, and therefore the fire is even then in motion.

Again, animals of all kinds live even in the most piercing cold: and the spirit it self remains fluid. All which plainly evinces the perpetual mobility of fire.

*Fire in ice.*

Who would imagine that there should be fire even in ice? and yet I have made an artificial cold greater by 12 degrees, than that of ice; so that had the thermometer, wherewith the extremest cold was measur'd, been applied to ice, the spirit therein would have risen 12 degrees ||.

*All fire naturally vague and undetermined.*

Now this motion of fire is perfectly indifferent, and without any particular determination this way, more than that. Thus much we easily gather hence, that fire has no particular attractive, and that there is no other cause to induce it to go to one place, rather than other.

And hence, unless either the action of the sun, or some attrition intervene, to determine, and collect the fire; it would always remain the same in all places. Hence also it is, that a living man is warm even in the severest cold; and a dead one, cold in the most sultry heat.

*Nature of the sun.*

It were foreign to our purpose here, to enter into a particular discussion about the matter of the sun, and whether it be fire. To us it appears very extraordinary, that the sun, after a continual emission of corpuscles of fire upwards of 5000 years, should not yet be exhausted *. 'Tis much safer to say,

ty of the mirror, and reflected. Hence, if our eyes were a good deal sharper than they are, and much more easily affected, we should see a continual light streaming from us both by night and day. So that the human body is a sort of luminary or radiating fire, tho' a very weak one. *Boerhaave, cod. impress.*

† *Il est donc constant que la* Matiere *de la Lumiere est continuellement en mouvement, & agissante sur tous les corps poreux que sont dans l'univers.* Homberg, *Essai du souffre principe.*

|| "It seems extravagant to talk of heating cold liquors with ice; but I have easily done it, by taking out of a bason of cold water, wherein several fragments of ice were swimming, one piece or two, which I perceived very well drenched with the liquor, and suddenly immersing them into a wide-mouth'd glass, of strong oil of vitriol: for the menstruum presently mixing with the water which adhered to the ice, produced in it a brisk heat, sometimes with a manifest smoke; and that suddenly dissolving the contiguous parts of the ice, and those the next, the whole ice was soon reduced to water; and the corrosive menstruum being, by two or three shakes, well dispersed thro' it, the whole mixture would immediately grow so hot, that sometimes the containing vial could not be endured in one's hand. *Boyle. Mech. Prod. of Heat.*

* "The sun and stars, according to Sir *Is. Newton*'s conjecture, are no other than great earths, vehemently heated: for large bodies, he observes, preserve their heat the longest, their parts heating one another; and why may not "great,

ſay, that it has the power of determining fire, than that it furniſhes it. The caſe may be the ſame as in M. *Villette*'s mirror, which when expoſed to the naked ſun produces ſuch amazing effects, and yet has no effect at all, if the ſun be but cover'd from it, by the interpoſition of a cloud, or the like: the mirror may appear the cauſe of burning; but 'tis only an inſtrument neceſſary thereto: and the ſun may be no more.

If now the ſun impel the matter of the fire, in right lines, we call it *lux*, light; which light is not any fiery corpuſcles, in the ſun it ſelf, but the vague fire abovemention'd, put in a new determination by the ſun, and collected into ſome one place. For, as already obſerved, the intenſeſt light, without this determination, will leave us in the utmoſt night. *What light is?*

This fire, again, will never yield light, unleſs directed, and impell'd in right lines.

After the ſame manner ariſes what we call *lumen*, luſtre, which is light it ſelf directed by a luminary, and again reflected from an opake body. For light to produce a luſtre, 'tis neceſſary it be likewiſe reflected in right lines: for no body will be luminous unleſs either the ſun ſhine, or ſome other body ſupply its place, and direct the light in the ſame manner, *i. e.* in right lines. *What luſtre is?*

Hence alſo ariſes *heat*. For all heat depends on fire; nor is it felt, unleſs increaſed in proportion to our ſenſes, *i. e.* ſo as to be capable of affecting our organs.

While the ſun is above the horizon, he impels all the rays, before vague and fluctuating, toward a *focus*; and ſuch impulſion or determination is always in right lines: ſo that all our light, heat, and colour, is the effect of a rectilinear motion. Suppoſe, for inſtance, a fire, in a dark place, and a thermometer placed at a certain diſtance therefrom, with an iron-plate between them: In this caſe the thermometer will not be affected by the fire, by reaſon the rectilinear paſſage of the rays of heat is ſtop'd. Nor need it be added, that, under the like circumſtances, no light, colour, &c. is perceivable: So that none of theſe act but in right lines.

If there were no ſun, nor any body to ſupply its place, there would be no heat; *i. e.* the fire would not be determined in right lines: So that the

" great, denſe, and fixed bodies, when " heated beyond a certain degree, emit " light ſo copiouſly, as by the emiſſion " and re-action thereof, and the reflec- " tions and refractions of the rays within " the pores, to grow ſtill hotter, till they " arrive at ſuch a period of heat as is " that of the ſun? Their parts may be " further preſerv'd from fuming away, " not only by their fixity, but by the vaſt " weight and denſity of the atmoſpheres " incumbent on them, and ſtrongly com- " preſſing them, and condenſing the va- " pours and exhalations ariſing from them. " Thus, we ſee that warm water, in an " exhauſted receiver, ſhall boil as vehe- " mently as the hotteſt water, open to " the air; the weight of the incumbent " atmoſphere, in this latter caſe, keeping " down the vapours, and hindering the " ebullition, till it has conceiv'd its ut- " moſt degree of heat. So, alſo, a mix- " ture of tin and lead, put on a red hot " iron *in vacuo*, emits a fume and flame: " but the ſame mixture in the open air, " by reaſon of the incumbent atmoſphere, " does not emit the leaſt ſenſible flame." *Ibid. Optic.*

ſun is the father of all heat; or ſome other body, that acts in the ſame manner as the ſun: For the ſun does not make heat, but only the difference between the heat of the day and night. The exceſs of heat which we feel by day, is not owing to the matter of the fire, but to the ſun. For as to the quantity of fire, we have already obſerved, 'tis the ſame by night, as by day; and that 'tis the determination in parallel lines, that makes the difference in point of heat: Thus, nobody would imagine, upon ſtretching forth his hand, that it ſhould be preſs'd as with a huge weight, both upward and downward, as if pinched in a preſs; and yet there is no diſpute as to the fact: And the only reaſon why he is not ſenſible of it, is, that the preſſure is equal every way. So it is with fire, which, when equally moved every way, does not give any ſenſible heat; but when the ſun ſhines, he moves or directs it in right lines, and thus renders its heat perceivable *. It may be doubted, therefore, whether the ſun, for all his ſpots, be a hot body; ſince, if he were really ſo, he muſt tranſmit us more fire in winter than in ſummer †.

*The ſun's being a hot body doubted.*

After the ſame manner ariſe *colours*, which are nothing elſe but the matter of fire driven in parallel lines; without which motion, there would no ſuch thing ever be ſeen.

*The intenſeneſs of heat not increaſed in the ſame ratio as the quantity of fire.*

If, now, the particles of fire, before moving in a parallel direction, become determined a-new, in lines that converge; the effect of the fire muſt, of neceſſity, be heighten'd; by reaſon, a larger quantity of fire is, by ſuch means, collected into one place. And, were it not, that by ſuch increaſe of quantity its particles have a greater attrition, the forces of fire would be proportional to the ſpaces it poſſeſſed. But in bringing the particles ſo near, 'tis impoſſible but they muſt ſtrike on each other; and hence, the nearer they approach, the greater and quicker the attrition; and a brisk attri-

* 'Tis not very difficult to conceive, how fire ſhould become ſenſible either to the feeling, or ſight, by being thus determined in right lines. By ſuch determination, the vague, fluctuating corpuſcles, are form'd into rays, and a train of them driven upon the organ in a conſtant ſucceſſion. Hence, each ſubſequent one ſeconding the effort of the precedent one, the impreſſion, by ſuch a ſeries of augmentations, at length is felt. Thus the air, wherewith we are every way ſurrounded, if left at liberty, is not perceiv'd; but if its particles be driven or directed in a ſtream, whether by a pair of bellows, or any other cauſe that excites a wind, the impreſſion it makes will be very ſenſible.

† It has often been wonder'd why in *Nova Zembla*, the ſun ſhould never have power to melt the ice; notwithſtanding, that, for the ſpace of ſome weeks, his brightneſs is not leſs conſpicuous than with us. So the *Dutch*, who winter'd in that unhappy region, expected no leſs, than that in the month of *July* the ſea ſhould be thaw'd, and they left at liberty to purſue their voyage; but were miſtaken. This gave my Lord *Bacon* occaſion to obſerve, that the ſun's direct rays have no ſenſible effect, not even on a level country; nor yet the reflected rays, unleſs the line of reflection be near that of incidence; *i. e.* unleſs the angle intercepted between them, be very ſmall: ſo that they may, as it were, ſtrengthen and increaſe the effect of each other. Now the more perpendicularly the rays fall, the ſmaller is this angle: Hence, in *Nova Zembla*, where they fall extremely obliquely, the rays, by reflection, are ſever'd and diſperſed, and their effect thus render'd inſenſible. *Bacon de Forma Calid.*

attrition, we ſhall hereafter ſhew, does collect fire of itſelf. If, then, the quantity of fire, in any place, be increaſed, *e. gr.* ſix-fold, the attrition will of conſequence be augmented proportionably thereto. So that the force of fire does not only increaſe in the inverſe ratio of the ſpaces, but alſo in the ratio of the increaſe of attrition. *Effect of the attrition of the particles of fire when near each other.*

Beſide, the very vicinity of the particles to one another, gives them new power; inaſmuch as the force of attraction between them, is hereby increaſed. Thus, the load-ſtone and iron placed far aſunder, have no effect on one another; but brought nearer, begin to act; and this the more ſtrongly, as their diſtance is leſs. According to Sir *I. Newton's* experiments, theſe powers increaſe in the reciprocal ratio of the ſquares of the diſtances of the bodies; at leaſt this law is found to obtain in electrical bodies. Hence, fire does not only act more ſtrongly, as two particles thereof come to be collected into the ſame place where before there was but one; but as thoſe two, being now united, attract each other more ſtrongly, and act with united force. Tho' how much this additional force is, cannot be preciſely determined; ſince we can only meaſure the relative quantity of fire, not the real or abſolute one. *New power derived hence.*

And hence appears the nature of *Dioptrics*, whoſe office is to explain the changes which the fire undergoes in paſſing thro' tranſparent bodies; and the laws wherein they are effected: as, that convex glaſſes, in refracting the rays of light, collect them into a point, call'd the *focus:* That concave glaſſes in refracting, diſperſe the rays, &c. *Buſineſs of dioptrics.*

Hence, alſo, the foundation of *Catoptrics*, which teaches by what laws the rays of light ſtriking on opake bodies, are reflected from the ſame. As, in concave mirrors, which reflecting the rays, make them converge into a *focus*; or convex ones, which diſperſe, or render them divergent. Several perſons have attempted to find the quantity of light collected by a concave ſpeculum: But the thing, to us, appears impracticable; by reaſon there is no body in nature that reflects in all its points, or that is without pores, which receive and abſorb the light. *Of catoptrics.*

Now, fire, determined by the ſun, after the manner above-mentioned, toward the earth, does there acquire new powers, either in being acted on *catoptrically*; or, 2°, *dioptrically*; or, 3°, in undergoing a greater degree of *attrition.*

And hence ariſes another ſubordinate manner of collecting fire; for what was determined by the ſun into parallel rays, might either be diffuſed again, or lock'd up and loſt; which laſt is the caſe in black bodies, which are known to collect fire in greater quantity than others; as appears hence, that black clothes are found by the thermometer conſiderably hotter than white ones*: The reaſon hereof is, that the black ſuffocate, and abſorb *Black bodies gather more fire than others.* *Inſtanced in black clothes.*

* This extraordinary ſuſceptibility of heat in black bodies, Sir *I. Newton* accounts for hence, that the rays of light falling on them, are not either reflected from them, or tranſmitted thro' them; but, entering the bodies, undergo a great number of reflections and refractions within, till their motion be ſpent, and, conſequently, their heat, &c. loſt; *i. e.* according to him, till they ceaſe to be fire: but what motion and heat they themſelves loſe, the body receives.

ſuch rays as fall upon them; whereas the white reflect them back again. And to the ſame cauſe it is owing, that black and white clothes being both dipt at the ſame time in cold water, and thus hung up to the ſun, the black dries in a third or fourth part of the time required to dry the white: as is known to every dyer. So alſo a black ſoil is much hotter, *cæteris paribus*, than any other. This the peaſants, who inhabit the moraſs *de Veenen*, where turf is dug, are very ſenſible of: Walking there but a little while, your feet ſhall grow extremely hot with the ſoil; but your face not at all: on the contrary, in a ſandy place, the feet are ſcarce warm, when the face is ſcorch'd, by the great reflection.

*A black ſoil.*

Some maintain, that fire acts with the more force, as the reſiſtance of the medium is leſs; but the contrary is true: for fire would be incapable of warming, unleſs either reflected, or collected. The heat would be never the greater for the ſun's acting on the fire; unleſs, in its progreſs, it were either refracted or reflected, and by that means determined to one place more than another. And hence it is, that the cold, *cæteris paribus*, is always greateſt in ſtill weather; and that in the ſeverity of winter, and particularly froſty weather, the heavens are clear. Thus, alſo, the tops of the talleſt mountains, where the reflection and refraction are leſs conſiderable by reaſon of the want of clouds, are eternally cover'd with ſnow; as in *Peru*, *Mexico* †, the *Alps*, *&c.* And to the ſame cauſe it is owing, that the nights in *Armenia* are ſhivering cold.

Heat, then, depends not upon the fire's being ſent or determined toward us, but on its being reflected, either by mountains, or clouds.

If fire be propagated thro' an uniform medium, it will never produce any conſiderable heat. And hence it is, that the degree of heat is not ſo very intenſe in the torrid zone, as one would otherwiſe expect; but that in the iſland of *Ormus* ||, 'tis perfectly ſcorching, and not endurable by any mortal, unleſs they were to ſcreen themſelves under water. The caſe is, that the ſaid iſland is full of ſalt-rocks, which act like ſo many ſpecula, and reflect the light in great abundance: ſo that the iſland, at a diſtance, appears like one continued fire.

Heat, therefore, does not immediately depend on the ſun, but on bodies that reflect. Hence, in high places, and where the atmoſphere is very rare, the heat is extremely feeble; and *vice verſa*.

But it remains here to be obſerv'd, that, according as the direction of the ſun's rays is greater, or leſs; the greater or leſs heat is produced. For,

† In the mountainous places of theſe countries, we are told, there is no ſuch thing as pure water, but all ice. Plants make a ſhift to grow about the feet of the mountains; but higher up, no vegetable can live, not for want of food, but thro' the intenſeneſs of the cold. Men, ſtaying there but a little time, catch violent agues, which, with a little longer ſtay, grow incurable. *Boerhaave in MS.*

|| The heat is here ſaid to be ſo vehement, that people, like fiſhes, are forced to ſleep in ciſterns of water, with only the head out, which is kept ſuſpended by a contrivance for the purpoſe. Another cauſe which ſome alledge for this exceſſive heat, is, that the iſland was antiently full of white mountains, which having in time been all laid level, the whole ſurface of the iſland is white, and thus diſpoſed to reflect abundance of light. *Boerhaave in MS.*

1°, A

1°, A body ſtriking perpendicularly on another, acts on it with all its force.

2°, A body ſtriking obliquely againſt another, acts with the leſs force, the more it deviates from the perpendicular.

Now fire, directed by the ſun into right lines, muſt obſerve the ſame mechanical law as other bodies; and conſequently its action muſt be meaſured by the ſine of the angle of incidence. And hence fire ſtriking on any obſtacle, in a direction parallel thereto, has no ſenſible effect; by reaſon the proportion is almoſt infinite, *i. e.* nothing. Accordingly, Dr. *Halley* obſerves, that the ſun radiating on the earth, in the morning, has but little effect; but, that when rais'd to the Meridian, he acts with all his force.

Now this is owing to the atmoſphere, which being replete with an infinite number of corpuſcles, reflects more of the ſun's rays to the earth, when they fall perpendicularly, than would otherwiſe arrive there. For, whereas, falling obliquely, they would be reflected, and thus be thrown off, and diſperſed into other parts: Now, that their incidence is perpendicular, they will paſs directly thro'.

And hence ariſes what is frequently obſerved by the ſailors, *viz.* that when the ſun radiates obliquely upon the ſea, as in the evening, there is no enduring his rays; by reaſon they are all reflected from the water, and ſcarce any loſt therein: So that the rectitude, or obliquity of the rays, contribute very conſiderably to the collecting of fire. And this obliquity, *&c.* is to be conſider'd in a twofold reſpect; both with reſpect to the matters in the atmoſphere, and to the ſurface of the earth.

Now, heat may be varied two ways.

*Heat various, according to the ſtate of the atmoſphere.*

1°, By means of the atmoſphere: For this does not always remain the ſame. Thus, *e. gr.* water is naturally tranſparent; and if you warm it, it ſtill retains its tranſparency: but if you make it boil, the vapour iſſuing from it, tho' perhaps a million times rarer than the primitive water, will not be tranſparent, but opake; by reaſon its parts are now in a different arrangement. And hence thoſe legions of corpuſcles every where floating in the vaſt receptacle of the atmoſphere, whenever they acquire a different diſpoſition, which they frequently do, alter the collection of the rays on the earth.

*Clouds act as burning-glaſſes.*

Add, that thoſe white clouds which appear in ſummer-time, are as it were ſo many mirrours, and occaſion exceſſive heat. Theſe cloudy mirrours are ſometimes round, ſometimes concave, polygonous, *&c.* When the face of heaven is covered with ſuch white clouds, the ſun ſhining among them, muſt of neceſſity produce a vehement heat; ſince many of his rays, which would otherwiſe, perhaps, never touch our earth, are hereby reflected to us: Thus, if the ſun be on one ſide, and the clouds on the oppoſite one; they will be perfect burning-glaſſes. And hence the phænomena of thunder, *&c.*

I have ſometimes obſerved a kind of hollow clouds, full of hail and ſnow; during the continuance of which, the heat was extreme; ſince, by ſuch condenſation, they were enabled to reflect much more ſtrongly. Af-

ter this came a ſharp cold, and then the clouds diſcharged their hail in great quantity: To which ſucceeded a moderate warmth. Frozen, concave clouds, therefore, by their great reflections, produce a vigorous heat; and the ſame, when reſolved, exceſſive cold. Hence, 'tis probable, that thunder is only produced, when ſuch concave clouds, before convolved into ſpherical figures, are driven with oppoſite motions againſt each other; and the rays tranſmitted thro' thoſe ſpheres, form burning *foci.* All clouds, 'tis probable, contain ſnow and ice; but theſe, in their fall thro' the warmer regions of the atmoſphere nearer earth, liquify, and diſtill in drops.

*Thunder how produced.*

The meteors in the atmoſphere have likewiſe their ſhare in reflecting of fire. Theſe, in effect, are a ſort of wandering fires, viſible by night, and which determine the fire over and upon the earth.

*Heat various according to the ſituation of the earth.*

2°, It is varied by means of the earth: For, as the ſurface of the earth varies, ſo muſt the heat. Thus, ſandy places reflecting more rays than others, muſt excite a greater degree of heat.

On the higheſt mountains, we always find the moſt cold, ſnow, and hail. In the ſultry region of *Peru*, the mountains are all ſummer long cover'd with ſnow; by reaſon they only receive direct, and but little reflected fire; and the effect of fire ariſing merely from being determined by the ſun into a parallelism, is found, by computation, to be very inconſiderable. For this effect, as already obſerved, is greater in winter than ſummer. Tho' the ſun be in his apogee in ſummer, and his perigee in winter; yet will a night's ice bear his ſhining upon it five or ſix hours, e'er it be thawn. And if, as the ſun riſes nearer toward the zenith, the ice and ſnow at length begin to run; this is not owing to the greater force of the ſun, but to the greater reflection, and collection of his rays from the circumſtances and poſition of the atmoſphere and earth. But the higheſt tops of hills are always free of ſnow: The reaſon whereof is, that water, *i. e.* the vapours and exhalations emitted therefrom, never riſe by the ſun's action above a mile high. But there are mountains a mile and a half high: To the tops of theſe, therefore, vapour, and conſequently clouds, can never mount. And hence it is, that in very high mountains, as the *Pico de Theide* in *Bohemia*, tho' the middle part be eternally inveſted with ice and ſnow, and the bottom ſcorch'd with intolerable heat; yet, on the top, you find yourſelf in a pure, thin, ſerene air, and view the clouds hovering at a conſiderable diſtance below you. Hence, alſo, it is, that all thunder is confined within leſs than a mile's height. Add, that in caverns, and the hollow parts under ground, the heat is found very great: ſo that the air is coldeſt in the higheſt places, and hotteſt in the loweſt; but in the intermediate atmoſphere, very unequal.

Heat, therefore, depends on clouds, mountains, *&c*, which reflect the light variouſly; and on the direction of the ſun's rays, or the poſition of his body with reſpect to us.

Hence, again, we gather that fire is the univerſal cauſe of all the motions about our earth: For, all fluidity depends on fire; and, accordingly, in

in the large burning-glaſſes, the firmeſt bodies become fluid, and evaporate in fume: and the more fluid any body is, the more fire it contains *: Whence

* Tho' fire be the great cauſe of fluidity, and motion; yet is it frequently found in ſuch ſmall quantity, that, inſtead of fuſing, or keeping them in a ſtate of fuſion, it becomes incloſed, and fixed therein, ſo as to remain, as it were, impriſoned, till ſome external cauſe come to its aſſiſtance, and open the cells which before retain'd it.

This is the caſe in quick lime, as alſo in lead, tin, regulus of antimony, &c. when calcined: In which the younger *Lemery* obſerves two things: 1°, That the fire thus incloſed, makes a ſenſible addition to the weight of the body; amounting ſometimes to one tenth of the whole: And, 2°, That during this impriſonment it ſtill retains all the particular properties or characters of fire; as appears hence, that when once ſet at liberty again, it has all the effects of other fire. Thus, a ſtony or ſaline body being calcined, and water poured on them; that fluid is found ſufficient, by its external impreſſion, to break up the cells, and let the fire out: and upon this the water is render'd more or leſs warm, according to the quantity of fire lodg'd therein. Hence, alſo, it is, that as ſome of theſe bodies contain a deal of fire; and the ſlighteſt occaſion is capable of diſengaging it: upon applying them to the ſkin, they burn, and raiſe an eſchar not unlike that of a live coal.

To this it is objected, that the particles of fire are only ſuch in virtue of the rapid motion wherewith they are agitated: So that to ſuppoſe them fixed in the pores of a body, is to diveſt them at once of that which conſtituted them fire; and, conſequently, to diſqualify them for producing the effects aſcribed to them. To which M. *Lemery* anſwers, that tho' the rapid motion of fire do contribute very greatly to its effects; yet, the particular figure of its particles is to be conſider'd withal. And tho' fire ſhould be detain'd, and fixed in the ſubſtance of bodies; yet why ſhould it fare worſe than other fluids in the ſame circumſtances? Water, for inſtance, is a fluid, whoſe fluidity depends, as already obſerved, on fire; and, conſequently, is leſs fluid than fire: And yet, every day, water is incloſed in bodies of all ſorts, without loſing its fluidity, or any of the properties that characterize it. Add, that when water is froze, the motion of its parts is, doubtleſs, diſcontinued; and yet the figure of the particles remaining the ſame, it is ready to commence a fluid, as before, upon the leaſt warmth. Laſtly, tho' ſalt be allow'd to be the matter of taſtes, and that it has certain properties, ariſing chiefly from the figure of its parts; yet, it only acts when diſſolved; or, which amounts to the ſame, when it ſwims in a fluid proper to keep its parts in motion: yet is it not leſs ſalt, or leſs the matter of taſte, when not in a ſtate of diſſolution. To deſpoil it of that quality, the figure of its parts muſt be alter'd.

As to what may be further objected of the impoſſibility of fixing ſo fine, ſubtle, penetrative, and active a matter as fire, within the ſpongeous ſubſtance of a groſs, porous body; it will be of no great weight, unleſs it can be proved, that the pores of the cells are bigger than the ſame. If it be inſiſted, again, that a body which could find its way into a ſolid body, might get out again the ſame way; and that as it only penetrated the body, inaſmuch as its own corpuſcles were ſmaller than the pores; ſo, the ſame pores muſt let it out again: It is anſwer'd, that the pores are not now in the ſame condition as before; the fire, in calcining, open'd, and dilated the pores; which, upon the fire's ceaſing, muſt cloſe, and contract again. *Mem. de l'Acad. An.* 1713.

"Tho' a great likeneſs might be ex-"pected," ſays Mr. *Boyle*, "between the "particles of fire adhering to quick lime, "and thoſe of highly rectified ſpirit of "wine; yet I have not found, that the "affuſion of that ſpirit upon quick lime "produced any ſenſible heat, or viſible "diſſolution of the lime, tho' it ſeem'd to "be greedily ſuck'd in, as common water "would have been. And I further tried, "that

Whence it is, that water, deprived of all its fire, fixes into ice; and when expofed afrefh to the fire, refolves into water: and all fluids whatever, if deftitute of fire, would do the fame. Nor is it any objection that fpirit of wine, and oil of turpentine, do not freeze in the fevereft winter; for this is owing to the feeblenefs of the cold in our climate: And, tho' they do not abfolutely congeal, yet we find them condenfe into at leaft three fourths of their former fpace. The truth is, there is no fuch thing in all nature as abfolute cold; the moft fevere we have ever known, was three years ago; when the water would freeze while it run down my hand: and yet even then, the cold was not fo compleat, but that I could make an artificial cold greater by twelve degrees. Air, the lefs warm, the denfer it is; and, 'tis more than probable, that, were it perfectly clear'd of all fire, it would become abfolutely rigid.

The caufe, therefore, why bodies do not cohere more firmly than they do, is the action of the fire: And hence, it is fire alone that gives bodies their motion; confequently, the caufe of all mutation in bodies, depends on the fame fire, which is never at reft, but always acts the more forcibly on bodies, as they are the more folid, *i. e.* as they make the greater refiftance to it: Whence it is, that gold admits a much greater degree of heat than other bodies. And thus, all rarefactions, maturations, vegetations, diftil-

"that if cold water were poured on the "fame lime, fo drenched, there enfued "no manifeft heat; nor did the lump ap-"pear fwell'd or broken, till fome hours "after; which feems to argue, that the "texture of the lime admitted fome par-"ticles of the fpirit of wine into fome of "its pores, which were either larger, or "more fit, without admitting it into the "moft numerous, whereinto the liquor "muft be received, to be able fuddenly "to diffipate the corpufcles of lime into "their minuter particles." *Boyle Mech. Orig. of Heat, &c.*

"Thefe phænomena feem to fhew, that "the difpofition which lime has to grow "hot with water, greatly depends on "fome peculiar texture; fince the a-"queous parts, which one would think "capable of quenching moft of the fiery "atoms fuppofed to adhere to quick lime, "did not near fo much weaken the dif-"pofition of it to heat, as that accefs of "the fpirituous corpufcles, and their con-"texture with thofe of the lime, in-"creafed it." *Boyle Mech. Orig. of Heat, &c.*

"If, inftead of cold water, you quench "the lime with hot water, the ebullition "will be, oftentimes, far greater than if the "liquor were cold. And this might well "be expected, hot water being much "fitter than cold, fuddenly to pervade "the body of the lime, and haftily dif-"folve, and fet at liberty the fiery and "faline parts, wherewith it abounds. And "what a greater intereft falts may have "in producing fuch heats than cold, I "have alfo tried, by pouring acid fpirits, "and, particularly, fpirit of falt, upon "good quick lime. For by this means "there would be a far greater degree of "heat excited, than if I had ufed common "water; and this, whether I employ'd "the fpirit cold or hot." *Boyle Hift. of Cold.*

"It is not eafy," fays the fame author, "to apprehend how fuch light and mi-"nute bodies, fhould be fo long detained, "as muft by this hypothefis be allowed, "in quick lime efpecially; fince no great "heat enfues the pouring of water upon "*minium*, or *crocus martis per fe*, tho' they "have been calcined by a violent fire, "the effluvia whereof feem to adhere to "them, by the increafe of weight the "lead and iron manifeftly receive from "the operation of it." *Boyle Mech. Orig. of Heat.*

lations,

lations, fermentations, effervefcencies, &c. are perform'd by this fire, in fubterranean places *.

### *Second way of collecting fire.*

THIS is by *attrition*, and does not confift in directing the fire into parallel lines, but merely in collecting it. Now, attrition or friction is a fwift motion of two bodies, whofe furfaces are applied againft each other; the fwiftnefs being fuch, in the prefent cafe, as that nothing but fire can follow, or keep pace with it. *Attrition collects fire.*

For the motion of a body, we obferve, may be fo far accelerated, as that air cannot fucceed faft enough into the places continually relinquifhed thereby: And hence fire, the fwifteft body in nature, immediately flips into the place, and by this means becomes collected in the path of the moving body. So that the moveable has, as it were, a fiery atmofphere around it. *And how.*

So, the axes of wheels of carriages, fwiftly driven, or heavily loaden; mill-ftones, when rapidly turn'd by a too violent wind, or ftream of water; iron held againft the grind-ftone; and ropes of fhips, &c. vehemently preffed againft their pullies, conceive heat, and frequently break out into flame. And the harder and more elaftic the bodies are, the greater the force wherewith they are prefs'd againft each other, the larger their furface, and the fwifter they are moved; the more fire will they collect. Thus fteel, *cæteris paribus*, ftrikes fire fafter than iron; and a diamond, by friction, conceives heat the fooneft of all bodies: So gold retains heat the longeft, &c. *And in what law.*

Thus, the *Indians*, who don't know the ufe of the flint and fteel, have an extraordinary kind of wood call'd *Sideroxylis*, which, when briskly rubb'd on another piece of the fame, yields fparks both more readily, and plentifully than our flint, &c †.

Now

* Hiftorians relate, that the fun, for a whole year together, appear'd pale, and obfcure; his face being cover'd over with dark fpots; fo that his luftre fcarce exceeded that of the moon. The effect hereof was, not a very extreme cold, but a general languifhment and deftruction of all things. And yet there was not lefs fire in our atmofphere than at other times; but only that fire wanted the neceffary direction. *Boerhaave Ced. Impref.*

† A large glafs-tube rubb'd on a linen or woollen-cloth, will emit light in the dark; and the tube thus heated, acquires a fenfible electricity. *s'Gravefande Element. Phyf. Math.*

A globe of glafs eight or ten inches in diameter, being put in a frame where it may be fwiftly turn'd about its axis; will, in turning, fhine, where it rubs againft the palm of the hand applied to it: And if, at the fame time, a piece of white paper, or white cloth, or the end of one's finger be held at the diftance of about a quarter of an inch from that part of the glafs where it is moft in motion; the electric vapour excited by the friction of the glafs againft the hand, in ftriking againft the paper, cloth, or finger, will be put into fuch agitation, as to emit light, and make the white paper, cloth, or finger, appear lucid like a glow-worm;



and

Now this attrition may happen either in the air or the earth, infinite ways; and hence arife thofe fudden flufhing heats we fometimes feel: Thus, oil, vitriol, and water, mix'd, make a vehement attrition, the effect whereof is an intenfe heat. But inftances of fuch bodies are almoft infinite.

Both thefe kinds of fires, both that excited by the fun, and that by attrition, the chemift is to make ufe of; and direct them to his own ends, *viz.* the performing of operations.

*Nature of fire.*

We fhall now endeavour to explain the nature of fire; but, if by *nature* you underftand the thing itfelf, in that fenfe we do not know the nature of any one body; and he muft be arrogant, and vain, that imagines he does. No man will ever arrive to know what a grain of fand is; for God has made every thing he created, infinite: Accordingly, there is no one body, how fmall foever, but contains in it every thing that is contained in the whole univerfe: Thus, the leaft line may be divided into infinite parts; and hence all magnitudes are only confider'd comparatively.

So, when I fay, I here intend to explain the nature of fire; I mean, the manner wherein it acts; which is enough in confcience, tho' we do not know by what it acts: Thus no man could ever give a reafon why a body ftriking on another, fhould lofe of its own motion in proportion to its bulk; yet the mathematicians contentedly take the effect, and make ufe of it in the demonftrating of many other matters.

*Fire a body extended, impenetrable, moveable.*

1°, The firft thing we affirm concerning fire, is, that it is corporeal, *i.e.* confifts of an infinite number of corpufcles, or little bodies.

By body, *corpus*, we mean any thing extended, impenetrable, moveable, figurable, &c. Now, that fire is *extended*, nobody doubts; that it is *impenetrable*, is evident hence, that it excludes all other body out of the fpace itfelf poffeffes, and is excluded by them; and that it is *moveable*, will eafily

and in rufhing out of the glafs, will fometimes pufh againft the finger, fo as to be felt. *Newton ubi fup.*

We muft add, however, that the globe is to be firft exhaufted of air; in which cafe, both the inner and outer furface will appear all luminous: If it be not exhaufted, there will no light be feen in the body itfelf, but on bodies at a fmall diftance from it.

Hence, and from fome other experiments of the like kind, *s'Gravefande* infers, that the glafs has a kind of atmofphere in and about its furface, which is excited, and put into a vibratory motion by the friction; by which motion the fire contain'd in the glafs is expel'd; and that this atmofphere, and fire, are more eafily put in motion, and difcover themfelves more readily, upon the abfence of the air. *Ibid.*

Mr. *Boyle* furnifhes various inftances of the effect of friction in the production of heat: "Having caufed a piece of iron to "be turn'd, and placing my naked hand, "at a convenient diftance, to receive the "little fragments, as they flew off from "the rod; they were fo intenfely heated, "by the quick action of the tool upon "them, that they feem'd almoft like fo "many fparks of fire. And an expert "workman in brafs affured me, that the "heat in the little fragments thrown off, "when he turn'd that metal, were fome-"times very offenfive to his eyes; and "that, when he employed a rough tool, "which took off greater chips, he had "found the heat fo vehement, as not only "to fcorch his eye-lids, but the hard skin "of his hand." *Boyle, Effects of Languid Motion.*

be

be granted, ſince 'tis it gives motion to all things; and this by means of its own impenetrable reſiſtance. Thus, if you take a ſlender iron-needle, and ſuſtain it on the point of a pivot, and thus oppoſe one end of it to the *focus* of a large burning-glaſs; it will immediately be driven round: So that fire acts on, and moves bodies, by virtue of its own impenetrable reſiſtance.

*Fire made to drive a body round.*

Again, fire, we have ſaid, *expands* the air; and in order to that expanſion, it muſt give it motion; expanſion itſelf being no other than a certain motion: but nothing can move a reſiſting body, ſuch as is the air, out of one place to another, unleſs itſelf be a body in motion, and impenetrable by air. And the more ſolid a body is, and the greater reſiſtance it makes, the more does the fire act thereon. And hence it is, that gold admits of the greateſt heat of all bodies.

But what inconteſtably evinces the corpuſcles of fire, is the following experiment: Take a quantity of the pureſt mercury, put it in a glaſs-vial with a long neck; and thus keep it, the ſpace of a year in a gentle heat, not much greater than that of a healthy man; and it will be then found reduced into a ſolid maſs, with a conſiderable augmentation of its former weight, from the particles of fire receiv'd, and lodg'd therein. Add, that there are divers other bodies, whoſe weight the fire increaſes in calcining them. Thus, antimony, being expoſed in the *focus* of a ſmall burning-glaſs, emits a continual fume; ſo that one would imagine it would all exhale: and yet, upon taking it out again, it is found to have gain'd in weight *.

*Fixes and incorporates with ſeveral bodies.*

*With antimony.*

Farther,

* Mr. *Boyle* gives us ſeveral experiments to ſhew, "that fire and flame may incorporate with ſolid bodies, and increaſe their weight. Having diſpoſed a quantity of ſulphur, and a copper-plate, in a tall receiver, ſo, as that the plate was at a conſiderable diſtance from the ſulphur; upon firing the ſulphur, and letting it burn away, ſo as its flame reach'd the metal, the flame ſeem'd to have actually penetrated it, and to have made it viſibly ſwell, and grow thicker; which appear'd to be done by a real acceſſion of ſubſtance; ſince, after he had wiped off ſome little adhering ſordes, and, with them, ſeveral particles of copper, that ſtuck cloſe to them, the plate was found to weigh near thirty-two grains more than at firſt; and, conſequently, had increaſed its former weight above a fifth part. *Ponderab. of Fire and Flame.*

"Upon a very ſhallow crucible, we put one ounce of copper-plate, and ſet it in a cupelling furnace, where it was kept for two hours; and then being taken out, we weighed the copper, which had not been melted, (having firſt blown off all the aſhes) and found it had gained thirty grains. *Boyle, ibid.*

"Steel being a metal that, as experience informed me, will very eaſily be wrought on by fluids of a ſaline nature, 'twas reaſonable to expect, that flame would have a greater operation on it, eſpecially if it were beforehand reduced to ſmall parts, than on any bodies hitherto deſcribed. And, accordingly, four drams of the filings of ſteel, being kept two hours on a cupel, under a muffler, acquired one dram, $6\frac{1}{4}$ grains, increaſe of weight.

"A piece of refined ſilver being put upon a cupel under a muffler, and kept there for one hour and an half, was taken out, and weigh'd again; and as before it weigh'd three drams, $32\frac{1}{4}$

 "grains,

Farther, fire moves ſucceſſively *, and changes all bodies; which cannot be effected without contact.

Its motion may be ſtop'd, and that in any point of its progreſs; conſequently, it may be contain'd in a certain place.

" grains, it now weigh'd, in the ſame " ſcales, 3 drams, 34 $\frac{1}{2}$ grains. *Id. ibid.*

" And to prevent all ſuſpicion of any " increaſe of weight in the metal, ariſing " from ſmoke, or ſaline particles, getting " in at the mouth of the veſſel; I made " the experiment in glaſſes, hermetically " ſeal'd, as follows: In eight ounces of good " tin, carefully weighed, we hermetically " ſeal'd up in ſome tin, which had been, " before, partly calcined in a glaſs; being " melted again in a crucible, we weigh'd " out juſt eight ounces; and theſe we " put in a bolt-head of white glaſs, with " a neck above twenty inches long, which " being hermetically ſeal'd, after the " glaſs had been a while kept over the " fire, leſt it ſhould break by the rare- " faction of the air, the metal was kept " in fuſion for one hour and a quarter. " Being unwilling to venture the glaſs any " longer, it was taken from the fire, and " when it grew cold, the ſeal'd end was " broken off; but before I could have the " bottom cut out, I obſerv'd, that the " upper ſurface of the metal was very " darkly coloured, and very irregularly " rough; and the lower part had between " the bottom, and the under-ſide of the " lump, a pretty deal of looſe dark-co- " lour'd calx; tho' the neighbouring ſur- " face, and ſome places of the lump it- " ſelf, look'd by candle-light of a golden " colour. The lump, and the calx toge- " ther, were weigh'd in the ſame ſcales " carefully, when we found the weight " to have increaſed above twenty-three " grains; tho' all the calx we could eaſily " ſeparate, being weigh'd by itſelf, a- " mounted to near eighty grains. *Boyle Ponderab. of Fire and Flame.*

" We received this further information " from our experiments, that bodies very " ſpirituous, fugitive, and minute, may, " by being aſſociated with proper par- " ticles, tho' of quite another nature, ſo " change their former qualities, as to be " arreſted by a ſolid and ponderous body " to that degree, as not to be driven a- " way from it by a fire intenſe enough " to melt, and calcine metals. For the " foregoing trials ſeem plainly to diſco- " ver, that even the agitated parts of " flame, minute enough to paſs thro' the " pores of glaſs itſelf, were, ſome way, " entangled among the metalline particles " of tin and lead; and thereby brought " to be ſo fixed, as to endure the heat " that keeps thoſe metals in fuſion, and " gradually reduce them to calces; a phæ- " nomenon that one would not eaſily look " for, eſpecially conſidering how ſimple " a texture that of lead or tin may be, " in compariſon of the more elaborate " ſtructures of many other bodies.

" And this phænomenon, which ſhews " us what light, and fugitive particles of " matter may permanently concur to the " compoſition of ponderous, and fixed bo- " dies, will, perhaps, afford uſeful hints " to the ſpeculative; eſpecially, if this " ſtrict combination of a ſpiritnous and " fugitive ſubſtance with ſuch as being " groſs and unwieldy, are leſs fit than " organized matter, to entangle or detain " them, be apply'd, as it may be, with " advantage, to thoſe aggregates of ſpiri- " tuous corpuſcles, and organical parts, " that make up the bodies of plants and " animals. And this hint may ſuggeſt a " conſiderable inference to be drawn " from the operation of the ſun beams on " appropriated ſubjects; ſuppoſing it to " prove like that flame of tin and lead." *Boyle Ponderab. of Fire and Flame.*

* It has been proved, that fire moves from one place to another; and, that ſuch a motion is not ſucceſſive, ſhould ſeem to imply a contradiction. We actually obſerve fire to fly off in vapours, and ſmoke; the fire, in ſuch caſes, carrying with it the volatile parts of the body it adhered to: The motion of the fire is certainly immenſely retarded by this acceſſion of other matter; and yet, under all this diſadvantage, its velocity is very great. *s'Graveſande, ibid.*

The

The ſame fire before diſperſed, may be collected into a certain place; and when collected, may be diſperſed again.

Fire, again, is alter'd in its progreſs, according to the different bodies and obſtacles it meets withal. For it is equally, and uniformly impel'd by the ſun; but falling on certain bodies, it is collected into focus's: ſo that its motion is alter'd according to the bodies that happen in its way.

Add, that it is refracted, and reflected, and obſerves all the ſtated laws of refraction and reflection which obtain in other bodies.

Since, then, fire has all the properties of body, we may ſafely conclude it to be body.

2°, The corpuſcles or molecules whereof fire conſiſts, are the *ſmalleſt* of all others; we mean, of all thoſe we know of. This is eaſily evinced, inaſmuch as it penetrates all known bodies, and there is none that denies it acceſs; for it paſſes even thro' gold, the moſt ſolid of all bodies. We can exclude water, oil, ſpirit, and all other fluids out of a body; but fire alone will eſcape, in ſpight of all our precaution. *The minuteſt and ſubtileſt of all bodies.*

If a fine ſilver wire be drawn, and cover'd over with the pureſt and cloſeſt gold, wherein the beſt microſcope cannot diſcover the leaſt pore; neither will the particles of fire paſs thro' the ſame, not even if it be applied to the aperture of a *camera obſcura.* And yet if you put a maſs of the moſt ſolid and pureſt gold in cold water, and leave it there till ſufficiently cool'd, and then taking it out, expoſe it to the open air; you will find it ſoon return to a degree of heat, equal to that of the medium; as will appear by the thermometer: Now, to return to the heat of the medium, is to receive or imbibe ſo much fire. Add, that in the Grand Duke of *Tuſcany*'s court was a hollow golden ball made, and fill'd with water; which being expoſed to the rays of the ſun, the water was ſoon heated thereby. After the like manner, a ſolid ball of gold being put in boiling water, the heat will penetrate to the very centre thereof; ſo that if you preſently cleave it into two hemiſpheres, and apply them to the thermometer, the ſpirit will riſe apace. Gold, then, occaſionally takes in or lets out a quantity of fire proportionable to what is contain'd in the ſame ſpace in the medium it is found in: So that there needs no further proof of fire's penetrating the moſt ſolid bodies; nay, of its paſſing thro' them with the ſame eaſe and freedom as thro' air. And hence it is, that there is the ſame quantity of fire contain'd in all bodies. *Penetrates all bodies.* *And even gold.*

Again, we are taught by *dioptrics*, that the ſmalleſt aperture or pore imaginable, will receive innumerable rays of fire at the ſame time, and all perfectly diſtinct, and without the leaſt confuſion among themſelves. *An infinite number of its rays will paſs thro' the ſmalleſt hole.*

Thus, take a plate of lead, make a perforation therein with the fineſt needle, and place it before a window, at which no light can enter; as in a *camera obſcura*; then, fixing a piece of paper on the wall oppoſite to the perforation: you will have a perfect and elegant repreſentation of all the external objects, as mountains, trees, houſes, rivers, &c. upon the paper. And as every thing is here repreſented perfectly diſtinct, 'tis evident the rays paſs'd thro' the aperture without blending at all. Since, then, thoſe

rays

rays are ſo exceedingly fine, that the rays of a whole hemiſphere ſhall paſs freely, without mixing, thro' a pin-hole; and light is nothing but fire: it follows, that the parts of fire are ſo minute, that they may paſs without any oppoſition, or loſs of force, thro' all the bodies in nature.

*Fire the moſt ſolid of all bodies.* 3°, Fire is the moſt *ſolid* of all bodies, *i. e.* conſiſts of the moſt ſolid particles; or, its elements the moſt immutable, as not admitting of being ſeparated into any leſſer corpuſcles. Solidity depends on a firm coheſion of the parts of a body: And hence, where the pores are feweſt, and conſequently the ſubſtance moſt, there the ſolidity is greateſt. There muſt be very few pores, therefore, and thoſe the ſmalleſt imaginable, in a body ſo exceedingly minute as fire; and thoſe there are, muſt be impervious to all other bodies, ſince we have already made appear, that fire itſelf is the ſmalleſt of all other bodies. Now, the larger a body is, and the more particles it conſiſts of, the more pores it muſt contain: Thus, two bodies being join'd to each other, can neither conſtitute the ſmalleſt, nor the ſolideſt body, by reaſon there will always be pores left in the juncture. *And whence.* And hence, a pound of gold muſt have more pores, and conſequently be much leſs ſolid than the ten thouſandth part of that quantity. So that the corpuſcles of fire, in being the minuteſt of all bodies, muſt likewiſe be the moſt ſolid.

*The ſmootheſt and moſt poliſh'd of bodies.* 4°, The fourth property of fire, is, that it is the moſt *polite* and ſmooth of all bodies; for thus we denominate a body which is perfectly equable and ſimilar in every part: *e. gr.* which appears every where figured alike, and has no roughneſſes or eminences. And ſuch a body is fire; for had it eminences, they muſt be leſs than fire itſelf; and, conſequently, fire might be ſtill made leſſer; nay, and of courſe, by the continual action and attrition of the fiery corpuſcles on each other, muſt be continually ſo: which implies a contradiction; it having already been granted, there is no body ſmaller than fire.

We have likewiſe ſhewn, that fire is the moſt ſolid of bodies; which it could not be, if it had aſperities; for then it muſt conſiſt of ſeveral parts, and conſequently admit of pores.

But it is allow'd, that ſlipperineſs depends on politure; and that fire is the moſt ſlippery of bodies, is evident from its particles moving in ſtraight lines, and in that they undergo no change by reflection, nor are any way intangled, but always paſs freely and alike thro' the moſt ſolid body. Whereas, were they rough, and ſcabrous, they muſt neceſſarily hinder each other's motion. Add, that if a ray thus tranſmitted thro' a little aperture, be examined; it will be found to anſwer the juſt laws of refraction and reflection; *i. e.* it makes its angles of incidence equal to the angles of reflection, and *vice verſa*: which it could not do, were it not extremely ſpherical and ſmooth: For, in all the doctrine of optics, catoptrics, and dioptrics, the refracted and reflected bodies there conſider'd, are ſuppoſed to be perfectly ſpherical.

*The ſimpleſt and moſt ſimilar of all bodies.* 5°, Fire is the moſt *ſimple* of all known bodies, and conſequently the moſt immutable.

By

By *ſimple* body we mean that which is the ſame in all and every its parts, as in the whole; or a body equally homogeneous in every part. Now, the ſimplicity of fire conſiſts, firſt, in this, that it has but few or ſmall pores; for, ſo far as it admitted of void and corporeal parts, it would be compound and heterogeneous: And, ſecondly, in the minuteneſs of its parts; for the bigger a body is, the more compound it muſt be.

Fire, therefore, muſt be admitted in the quality of the moſt ſimple of bodies; and eſpecially as it remains immutable, and always operates after the ſame manner.

Yet, what appears very ſtrange, fire itſelf, thus minute, ſolid, polite, and unchangeable, is not perfectly ſimple; and there are no leſs than three diverſities diſcover'd therein. *Differences of fire.*

1°, Firſt diverſity is in point of *colour.* The great Sir *I. Newton* has ſhewn, that one ſingle white ray of light, which all men imagined perfectly ſimple, and uncompounded, does really conſiſt of ſeven other different rays; which, when united together, conſtitute a beautiful white; but when ſeparated, appear to be violet, green, blue, orange, yellow, and red *.

Fire, therefore, which affords a white colour, is an aſſemblage of ſeven kinds of fire, of ſo many different colours. And who will affirm, that each, even of theſe *radioli*, does not conſiſt of as many more? Indeed, thro' the weakneſs of our ſight, 'tis poſſible we may never arrive to perceive them; ſo that our way, here, muſt be to take each of the ſeven as the moſt ſimple of all bodies; in reſpect, we mean, of our ſenſes. 'Tis but forty years ago, that a ray of light was held indiviſible; and now we can divide, and ſeparate it into ſeven other diſtinct rays; in the ſame manner, as if theſe ſeven fingers now cloſed into one group, were ſeparated into ſeven parts. Nor can it be aſſured, that each of theſe ſeven elemental rays is not, in like manner, compoſed of ſeven other leſſer threads.

2°, Another diverſity of fire lies in this, that each corpuſcle has ſides differently affected, and which have different properties: And, which muſt be allow'd no ſmall degree of ſubtlety, we can take one ſingle corpuſcle hereof; *e. gr.* a yellow or blue one, and apply its ſurface in ſuch manner to a reflecting or refracting body, that, with all its ſimplicity, it ſhall ſhew a difference in its ſides. *Its ſides have different powers.*

This Sir *I. Newton* firſt ſhew'd in *Iſland* cryſtal; which is found to attract a corpuſcle of fire, if one of its ſides be turn'd toward the cryſtal; and repel it, if the other be: or, while one and the ſame ray, *e. gr.* a blue one, is paſſing, one part of it is attracted while the other is repel'd †. *Iſland cryſtal.*

3°, The

* Every ſort of ray, as it is more or leſs inflected by refraction, has a particular colour. The rays, *e. gr.* leaſt bent by refraction, are red; thoſe next, orange; then yellow, green, blue, purple and violet; which laſt are the moſt refrangible. And ſuch colour of any ray is abſolutely unchangeable by any refractions, reflections, ſeparations, mixtions, &c.

† *Iſland* cryſtal is a tranſparent, fiſſile ſtone, of the nature of a talc: a piece hereof being laid on a book, every letter ſeen

*Particles of fire differently refrangible and reflexible.*

3°, The third diverſity is the different refrangibility and reflexibility of the different parts of light. This ariſes hence, that the parts are endued with a different attractive power; and, accordingly, attract, and are attracted by other bodies differently. Thus, a white ray, either paſſing thro' a body, or being reflected from it, its ſeveral component rays, *e. gr.* the red and blue, are differently attracted by the body; *i. e.* the blue more, the red leſs; and thus become differently refrangible, and reflexible: and by that means eaſily ſeparable from each other ||.

But

ſeen thro' it, will appear double; by means of a double refraction which it makes of the viſual rays in paſſing thro' it: And a ray of light falling on its ſurface, in any direction, becomes divided into two rays, from the ſame cauſe. Now, one of theſe refractions is perform'd, according to the uſual rule of optics; *i. e.* the ſine of incidence out of air into the cryſtal, is to the ſine of refraction as five to three: But the other, call'd the unuſual refraction, obſerves another rule; and the ray, which by the firſt ſurface of the cryſtal, was refracted after the uſual manner, upon paſſing the ſecond ſurface, is alſo refracted: ſo that both emerge out of the ſecond ſurface parallel to the incident beam: And the ſame will hold, if the rays paſs thro' ſeveral pieces of *Iſland* cryſtal placed parallel to each other; the ray refracted after the unuſual manner in the firſt ſurface of the firſt, being found to perſiſt in the ſame way, in all the ſurfaces of all the reſt.

Hence Sir *I. Newton* gathers, that there is an original difference in the rays of light, by means of which, ſome are conſtantly diſpoſed to be refracted after the uſual, and ſome after the unuſual manner; for if the difference were not original, but aroſe from ſome new modification which the rays underwent at their firſt refraction, it would be alter'd by new modifications in the following refractions. And this may give us a ſuſpicion of more original properties in light, than have yet been diſcover'd.

In effect, the rays of light appear to have ſeveral ſides, endued with ſeveral original properties; for the two rays, thus differently circumſtanced, are not of different natures, ſo, as that one in all poſitions of the cryſtal will be refracted after the one; and the other, after the other manner: all the difference between them conſiſts in the different poſition of the ſides of the ray to the planes of perpendicular refraction: And the ſame ray, in this or that poſition of its ſides to the cryſtal, will be refracted either in the uſual or the unuſual manner. *Newton. Optic.*

|| The reflection of the rays, Sir *I. Newton* ſhews, does not ariſe from their ſtriking on the ſolid, impervious particles of bodies: ſuch reflected rays, tho' they approach infinitely near the body, never touch it; for all thoſe which do touch, are loſt and extinguiſhed in the body. The power by which the particles are reflected, is not the immediate reſiſtance of any particles ſtruck upon; but a power equably diffuſed throughout the whole ſurface of the body, whereby it acts on light, either attracting or repelling it without contact: which power is the ſame with that whereby, in other circumſtances, the rays are refracted; and by which, alſo, they are firſt emitted from the luminous body.

And hence it is, that where light paſſes without refraction, there it alſo paſſes without reflection; that where the refraction is ſtrongeſt, there the reflection is ſo likewiſe; that light, paſſing out of a denſer into a rarer medium, is more copiouſly reflected, than in paſſing from a rarer into a denſer; and the reflection is the greater, as the difference of denſity in the mediums, is greater. Add, that every ray of light, in its paſſage thro' any refracting ſurface, is obſerv'd to be put into a certain tranſient ſtate, which returns at equal intervals, whereby it is diſpoſed to be now eaſily refracted, and then eaſily reflected. Theſe alternate fits of eaſy reflection, and eaſy tranſmiſſion, Sir *Iſaac* accounts for, from the vi-

But for Sir *I. Newton*, who firſt diſcover'd all theſe diverſities in fire, which plainly argue it a compound body, we ſhould have taken it for a perfectly ſimple one. But God has laid up infinites, even in the *minima naturæ*.

6°, Fire moves with the greateſt velocity of all bodies. *Fire the ſwiftest of all bodies.*

The antients all maintain'd, that light moved inſtantaneouſly; which opinion is countenanced by many obſervations of the eclipſes of the ſun and moon.

But *O. Roemer* has endeavoured, from the eclipſes of *Jupiter*'s ſatellites, to ſhew, that it moves ſucceſſively, or in time; and that it employs eight * ſeconds in travelling from the ſun to the earth. Whence it ſhould follow, that the velocity of light exceeds that of a cannon-ball by 1314000 times. *How much it exceeds that of a cannon-ball*

But *Caſſini* and *Maraldi* conteſt *Roemer*'s obſervation; it ſeems, that what he had obſerved in one ſatellite, does not appear in the reſt. So that this point muſt be left to further diſcuſſion. In the mean time, what pleads ſtrongly for the ſucceſſive motion, is the following experiment: Take a veſſel full of cold water; and apply ſeveral thermometers at ſeveral diſtances from the ſame: and you will find the heat diffuſe itſelf in concentric waves, arriving at thoſe neareſt it, firſt; and at the reſt in the order of their diſtance.

Sir *I. Newton* has even ſhewn, that light moves with greater velocity thro' denſe bodies, than thro' a *vacuum*.

From the whole, it appears, that the motion of fire is the firſt, and moſt univerſal of all motions: That this fire needs no *pabulum* to ſuſtain it; that it cannot either be created, or deſtroy'd, or produced: but, as 'tis impoſſible that fire ſhould ever not be fire; ſo likewiſe 'tis impoſſible, that what is not fire, ever ſhould be fire: And that the greateſt augmentations of fire are made by reflecting it, and bringing it nearer together. Thus, ſuppoſe a concave body, *e. gr.* a mirrour, conſiſting of any number of other concaves; expoſed to the ſun: The rays falling hereon, will be reflected at equal angles, and thus tend, converging toward a point where the fire will be moſt intenſe..

After the like manner, if a wall be hollow'd in a circle, or a ſegment thereof, and thus lined with plaſter, no body will be able to endure the heat it will project, when turn'd toward the ſun. *Mirrours made in walls.*

In *Saxony* there are burning mirrours made of wood turn'd ſpherically, lined with plaſter, and gilt over with leaf-gold; which have incredible effects: Nay, we are told of a peaſant that made a very powerful one of ſtraw, *Of wood.* *Of ſtraw.*

vibrations of a fine, ſubtle, ethereal, elaſtic medium; vaſtly finer, and more elaſtic than air, which penetrates thro' all bodies, and is diffuſed thro' all ſpace. The rays of light, by their attractive powers, or ſome other force, excite vibrations in this medium; which vibrations being ſwifter than the rays, overtake them ſucceſſively, and agitate them ſo as by turns to increaſe and decreaſe their velocities, and thereby put them into thoſe fits.

* "Light moves from the ſun to us, "the diſtance of about 70000000 *Engliſh* "miles, in about ſeven or eight minutes "of time." *Newton. ub: ſupra.*

ſtraw, by applying the poliſh'd ſides of the ſtraw, ſo as to form a ſegment of a ſphere. The fire reflected from this ſtramineous ſurface, would readily melt moſt metals; yet, itſelf, all the while remain cold and unhurt.

This is what we know of the nature of pure or elementary fire; *i. e.* theſe are the characters or properties of its action; which is the only knowledge the ſubject will afford us. And fire, with all theſe ſix characters or properties, may be collected in all places of the earth, and made obvious by its effects to our ſenſes: that, *e. gr.* found in the frigid zones, is juſtly the ſame as that near the equator: So, on the top of the pike of *Teneriff*, where the air is ſo very rare, that, like the *vacuum* of an air-pump, it ſcarce ſuffices to preſerve fire, and prevent its diſſipating and diſappearing; yet, the fire collected even here, tho' it ſcarce burn at all, has all the characters above enumerated.

We now proceed to vulgar fire.

## *Vulgar or common fire.*

*Vulgar fire.* BEſide elementary fire, hitherto diſcourſed of, there is another call'd vulgar or common fire: but this, in reality, is the ſame with the former, only under ſome difference of circumſtances.

*Collected by attrition.* It is collected, 1°, By attrition: Thus, when two bodies are violently rubb'd againſt each other, a real fire is excited: And thus, a ſteel and flint ſtruck againſt each other, even in winter, they will grow hot to ſuch a degree, as to give fire to ſulphur.

*Putrefaction of vegetables.* 2°, By the putrefying of vegetables, of what kind ſoever they be: Thus, throwing water on hay, and then preſſing it cloſe down, with a board over it, it ſoon ferments, grows warm, emits ſmoke, and at length breaks into flame. But this method depends on the air, which being here compreſſed, raiſes an attrition by the power wherewith it endeavours to expand, or ſet itſelf at liberty. And the ſame holds of all herbs.

*Vulgar fire of the ſame nature with elementary.* The fire thus produced, or rather thus collected, is pure fire, and diſcovers itſelf by all its effects, perfectly alike, and equal to, the elementary fire; only that it does not reſide in ſo pure a ſubſtance. Thus, that gather'd from horſes dung, moiſten'd with water, and cloſely preſſed, is found in all reſpects the ſame with that of a burning-glaſs; yet this dung is nothing but hay broke into very little pieces or ſhreds, and deprived of its juices. And the reaſon why the dung of other animals will not do the ſame, is, that horſes excrements are retain'd a conſiderable time in the little *ſacculi* of the inteſtines, while all the humidity may be expreſs'd. So that even a horſe's dung, when under a *Diarrhœa*, will not have the effect *.

* My Lord *Bacon*, indeed, ſuggeſts, that the fire produced by any putrefied thing, is very different from ſolar Fire. But this is a deception: for that produced by the dung of an animal, if it be received in a veſſel hermetically ſeal'd, is found to have the very ſame effect on the veſſel, and the matters therein contain'd, as the ſame degree of the ſun's fire. The dung, *e. gr.* of a horſe, being laid by itſelf for ſome time, grows incredibly hot. *Boerhaave Cod. Impreſ.*

3°, The

3°, The third way of collecting this fire, is by the admixture of chemical liquors: As when two liquors, which in themselves are cold, being mixed together, raise an effervescence, and at length a vehement heat †. By such means, a fire is sometimes produced beyond any thing the thermometer can measure. *Vulgar fire collected by the mixture of liquors.*

Thus, spirit of nitre, and oil of cloves, suddenly mix'd, raise a fire nothing inferior to that collected by M. *Villette*'s mirrour: or, in lieu of oil of cloves, any other oil, heavier than water, may be used: But such experiments are not made without great danger. This method of collecting fire was first discover'd by *Ol. Borrichius*. *Spirit of nitre and oil of cloves.*

4°, Fire is collected by the contiguity of air to certain bodies: *e. gr.* to phosphorus, which is a substance procurable from the putrefied parts of all animals and vegetables. For, after extracting the water, oil, and salt from the same, if you continue to urge them with a vehement fire, you will have a blueish smoke, which shines in the dark; and which, being caught in a receiver, and condensed by proper cold, constitutes what we call phosphorus ‖: which may be kept in water for twenty, nay forty years, without any diminution of its properties; but if expos'd to the air, immediately takes fire: whence it appears, that the mere attrition of the air may excite fire *. *By phosphorus.*

5th

† Take some ounces of strong oil of "vitriol, and shaking it with three or "four times its weight of common water; "tho' both the liquors were cold when "put together, yet in their mixture they "will immediately grow intensely hot, "and continue considerably so for some "time. *Boyle Mechan. Orig. of Heat.*

‖ Phosphori, in general, says M. *Lemery*, may be considered as so many spunges, full of fire, or the matter of light, which is so weakly retained therein, and by so slender a hold, that a small external force is sufficient to put it in a condition to exhale, in a lucid form, and sometimes even to burn the bodies that come in its way. *Mem. de l'Acad. An.* 1713.

* It has been above observ'd, that there is no body, which can be esteemed a magnet with respect to fire, *i. e.* no body which attracts it by any peculiar virtue, more than other; and yet our author here furnishes some considerations on phosphori, which seem to evince the contrary; at least as they are stated in the printed copy. "The fourth way of collecting "fire, he observes, is in some measure "magnetical, *i. e.* perform'd by means of "certain bodies peculiarly disposed to imbibe, and retain fire. For that there is "some peculiar agreement and attraction "between fire and certain bodies, is evident, among other things, from black "bodies, which, as already observed, absorb almost all the fire that falls on 'em, "whereas other bodies reflect a great "part of it, and some, all. Other instances of such agreement we have in "the phosphorus *Balduini*, and *Bononian* "stone; which when duly prepared have "all the characters of attractives: thus, "being immediately exposed in a dark "place, they do not afford any light; but "expose 'em first to the sun a while, and "they will then shine in the dark, as having imbibed a stock of fire, and lodg'd "it in their spongeous substance, to be "dispensed again by degrees. The like "may be said of the *phosphorus* made of "human urine, and other chemical preparations, which receive such a proportion of fire in the preparation, and retain it so well in their unctuous substance, that it shall keep there, in water, for 20 years: and upon the first "laying it open to the air, take fire, and "exhale in lucid fumes; leaving nothing "behind but an acid malagma, like oil of



sul-

*Fire collected by the mixture of two solid bodies.* 5th Way of collecting fire, is by two solid, quiescent bodies, moisten'd a little, then ground, mix'd together, and press'd with a proper weight. Thus, if you take equal portions of steel filings, and sulphur in powder, moisten 'em with a little water sufficient to form 'em into a sort of paste, and thus hide 'em under ground, well press'd down; they will smoke, heave, and at last catch a vehement flame †. Dr. *Lister*, in his writings

" sulphur *per campanam*, or oil of vitriol. " Not that we suppose the fire fix'd and " quiescent all the while in the body of " the phosphorus; for, that it has a real " motion all the while, is evident hence, " that if you observe it in any dark place, " in the summer time, you will find " it continually fulminating and emit- " ting flashes: tho' with all this it scarce " loses any thing of the fire. So that the " fire is not fix'd in the phosphorus, but in " a continual undulatory motion.

† " By putting a considerable quantity " of dry salt of tartar, in the palm of my " hand, and wetting it well with cold " water, there has been a very sensible " heat produced in the mixture: and " when I have made the trial, with a large " quantity of salt water, in a viol, the " heat proved very intense, and continued " to be sensible for a long time after. *Boyle Mech. Orig. of Heat.*

" 'Tis known that salt-petre being put " into common water, produces a sensi- " ble coldness therein, as it doth also in " many other liquors; but the same " salt, put into a liquor of another consti- " tution, may have a quite different effect; " appears by mixing 8 ounces of fine " salt-petre in powder, with 6 ounces of " oil of vitriol: for here a salt, not only " actually cold, but with regard to many " other bodies, potentially so, mix'd with " oil of vitriol, which is sensibly cold " too; quickly conceives a considerable de- " gree of heat, whose effects also become " visible in the plenty of fumes, emitted " by the heated mixture. And tho' gun- " powder seems to be of a very fine na- " ture, yet if some ounces of it, reduced " to a powder, be thrown into four or " five times as much water; it will very " manifestly impart a coldness to it; as ex- " perience made with, as well as without, " a seal'd thermometer, has assured me. *Ibid.*

" I have made an experiment, says Mr. " *Boyle*, in which two liquors, whereof " one was natural, did, by being several " times separated, and reconjoined with- " out addition, at each conjunction pro- " duce a sensible heat. An instance of " this kind we have in salt of tartar, from " which, after it had been once heated " by the affusion of water, we abstracted " the liquor without violence of fire, till " the salt was again dry; and then putting " on water a second time, the same salt " grew hot again in the viol, and produ- " ced the like heat a third time, and might " probably have done it oftener.

" Perhaps the heat may much depend " on the particular disposition of the cal- " cined body, which being deprived of its " former moisture, and made more po- " rous by the fire, acquires, by means of " those igneous effluvia, such a texture, " that the water, impelled by its own " weight, and the pressure of the atmo- " sphere, is able to get into a multitude of " its interstices at once; suddenly dissolve " the alkalizate salts it every where meets " with; and briskly disjoin the earthy and " solid particles that were blended with " them, which being exceeding nume- " rous, tho' each of them perhaps be " very minute, and moves but a very lit- " tle way, yet their multitude makes the " confused agitation of the whole aggre- " gate, and of the particles of the water " and salt, vehement enough to produce a " sensible heat. *Id. ibid.*

And the same that is here shewn of *heat*, does likewise appear of its oppo- site, cold. " Mr. *Boyle* observes, that a more " intense degree of cold may result from " a mixture, than was to be found in ei- " ther of the ingredients a-part; and al- " so that a considerable coldness may be " begun between bodies, neither of them " actually cold before they were put to- " gether.

writings upon fossils, observes, that the pyrites contains iron and sulphur; whence it is, that when a little moisten'd it takes fire. And hence, according to him, the pyrites under ground happening to be wash'd by rills or streams of water, kindles, and explodes: and thus arise earthquakes, vulcano's, *&c.*

These are the chief ways of collecting fire, from which appears how enormous the popular opinion is, that fire can only be produced either by the sun, or some fire already existing under the earth. We add, that the quantity of fire in the universe, is fix'd and immutable; and that in the instances now recited, we only collect more of it into one place, and consequently leave the less in another: so that the hotter one place is, the colder is another. Hence *Troy* cannot be burnt without robbing *Ida* of its fire: and thus water freezes so much the more readily, and the more strongly, as there is a greater fire not far off.

" gether. Having brought a glass full of " water to such a temper, that its warmth " made the spirit of wine in the sealed " weather-glass manifestly ascend, I took " out the thermometer and laid it in pow- " der'd sal-armoniac, warmed before hand, " whereby the tinged liquor was made to " ascend much quicker than just before by " the water; and having presently remov- " ed the instrument into that liquor again, " and poured the warmish sal-armoniac " into the same, I found, that within half " a minute or less, the spirit of wine be- " gun to subside, and fell above a whole " division and $\frac{1}{4}$ below the mark at which " it stood in the water, before the liquor " or salt were warmed. Nor did the spi- " rit in a great while reascend to the " height it had when the water was cold. *Ibid.*

" We took a small seal'd thermometer, " whose stem was divided into equal " parts, by little specks of amel, that sharp " liquors might not eat off, nor spoil the " marks. The ball of this instrument we " put into a slender cylindrical vessel, and " more than cover'd it with strong oil of " vitriol; and left it there a while to be " reduced to the temper of the surround- " ing liquor; then we cast upon it by de- " grees sal-armoniac well powder'd, which " being soon furiously wrought upon by " the menstruum, a seeming effervescence " was produced in the conflict, with " great noise and much froth, which more " than once was ready to run out of the " vessel. But for all this seeming ebulli- " tion, the mixture, instead of proving " hot, did really grow gradually colder, " as appeared not only to the touch, but " by the descent of the tinged spirit of " wine. But pouring this actually cold " mixture into three or four times its " weight of common water, which was " likewise actually cold; this second mix- " ture immediately grew so hot, that I " could not keep my finger, for a minute " or two upon the outside of the contain- " ing glass. *Id. ibid.*

" To 12 ounces of sal-armoniac we put, " by degrees, an equal weight of water; " and whilst the liquor dissolved the salt, " and by the action produced a great cold- " ness, we warily poured in 12 ounces of " good oil of vitriol; whence a notable " degree of heat was quickly produced in " the glass, wherein the ingredients were " mixed, though it seem'd unlikely, that " the two liquors, which usually with sal- " armoniac do each produce an intense " cold; should, upon acting together, " produce the contrary quality. *Id.* " *ibid.*

" In most of the experiments hitherto " proposed, cold is regularly produced in " a mechanical way; but in some sort of " trials, I found the event varied by un- " observed circumstances, so that mani- " fest coldness would be sometimes pro- " duced by mixing two bodies together, " which at another time, would upon u- " niting disclose a manifest heat; and " sometimes again, tho' more rarely, " would have but a very faint degree of " either. *Ibid.*

Away,

Away, then, with that empty dread, that the world may one day be consumed by fire: for, from what has already been shewn, 'tis impossible: We mean physically, so; and without setting aside the order of nature. Nor is the apprehension less vain, that we shall come at length to want fire.

## *Of the Pabulum, or Food of Fire.*

*Fire how it goes out, and in what law.* FIre, thus collected by attrition, *&c.* soon appears to perish: but in reality only disperses again, in which state, as already shewn, it does not affect our senses, and consequently perishes to us. Unless, therefore, the fire thus collected, be some way or other retain'd, it soon dissipates and disappears, which dissipation is found to be in the ratio of the density of the ignited body or medium, wherein it exists. Thus red-hot iron loses its heat much sooner in air than *in vacuo*; in water, 850 times sooner than in air; and in mercury vastly sooner than in water; and so of the rest: the extinction being always the quicker, as the medium is denser.

*Sustained by fuel.* Now, to prevent this dissipation of fire, it is to be sustain'd by some proper matter, which we call its *pabulum* or *fuel* ||. By *pabulum*, therefore, we mean any body, which applied to fire collected by any means, retains *Fuel what.* it in that state, and prevents its dispersion.

*Different from fire.* But this pabulum is not fire it self, nor is it at all convertible into fire: for if fire be set to spirit of wine, the whole of it will vanish, and be converted into flame; and yet the whole may be converted again into spirit by the appli- *Fuel after burning recoverable again.* cation of proper vessels. And the same holds of sulphur, or any other combustible body, the minutest part whereof is not lost in burning; as appears from trying it in vessels exactly clos'd. In vessels open to the air, indeed, a great part is lost, being carried off in flame, smoke, *&c.* But this only arises hence, that the principles into which the body is resolved by fire, are volatile. Hence it appears, that the pabulum of fire is not converted into fire, notwithstanding, that a great part of it disappears, when lighted in the open air, and to vulgar eyes seems converted into flame.

*Oil, or sulphur, the only proper fuel.* The only pabulum, or food of fire in all nature, is oil; commonly known under the name of sulphur *.

Thus,

|| "There are two ways of preserving "fire; first by bodies, which receive and "retain it, without being destroyed, or "dissipated thereby: and such are phosphori, above mentioned. The second by "affording it a continual supply of *fuel*, "*i. e.* of matter proper to retain it, till "being render'd volatile, and dispersed "in form of flame, fresh matter is added. *Boerhave, Cod. impress.*

* One great effect of the matter of light, diffused among terrestrial bodies, is, according to the younger *Lemery*, that being detained, and mix'd along with certain compositions of salt, earth and water, it therewith forms oils, fats, and in a word all inflammable matters, which are only such in virtue of the particles of fire they contain. What principally inclines us to this opinion, is, that in the analysis, such

Thus, in vegetables, which feed and ſuſtain fire, there is no other inflammable part but oil. For the water and ſalt, if thoroughly purg'd of all the oil, are found to damp and extinguiſh fire: and as to the ſpirit, neither does this burn; and the earthy part, no body will imagine, ſhould maintain fire; It may indeed retain it for a while; but no otherwiſe than as gold, or a ſtone ignited will do. Accordingly, extracting all the oil from a plant, it ceaſes to be any longer combuſtible. *Oil the only inflammable part in vegetables.*

This oil is found in two manners: firſt in a ſolid, and ſecondly in a fluid form: In the firſt, are the oils contained in all vegetable animal ſubſtances, and which appear in manner of a carbonaceous blackneſs. Thus, if you take a pound of the whiteſt wood, expoſe it in the middle of the fire, till it ceaſe ſmoking, and then plunge it in cold water; the white wood firſt converted into a ſhining, glowing brand, will now be a black coal. And the blackneſs here, is only the oil of the vegetable rarefied by the heat of the fire, and ſpread o'er the ſurface of the earthy part of the vegetable. If the coal remain too long in the fire, the oil, too, will be diſſipated, and nothing left but the bare white calx or earth. *Oil appears in two manners.* *A Coal what.*

The caſe is the ſame in animals, which have nothing inflammable in 'em beſide their oil. Their water and ſalt, freed of all oil, do by no means ſuſtain fire; and their earth is not at all combuſtible. Conſequently, animals can burn no longer than they have oil. This is evident hence, that the bones of animals, which while they retain'd their oil, would burn more fiercly than wood it ſelf; yet, when that is gone, ſo far are they from being combuſtible, that they make the greateſt oppoſition and reſiſtance to fire; as is evident from the refiners cuppels, which are made hereof. *Oil the only combuſtible part of animals.*

For foſſils, they, too, take fire, ſo far only as they contain ſulphur: their earth, water, and ſalts do none of them burn: nay, and their very ſulphurs, and bitumens remain incapable of firing, as to their ſaline and acid parts; and are only inflammable as to their oily ones. *And of foſſils.*

From what has been ſaid, we may gather, that oil is the only body in nature which can preſerve fire; and conſequently, in this view, oil may be deem'd a ſort of magnet or attractive, with reſpect to fire †. Now, oil is

ſuch bodies, are reduced into ſalt, earth, water, and a certain fine ſubtle matter which paſſes thro' the cloſeſt veſſels; ſo that what pains ſoever the artiſt uſes not to loſe any thing, he ſtill finds a conſiderable diminution of weight.

'Tis certain that ſalt, earth, and water, whether united together, or ſeparated, never become inflammable; but even hinder or retard it, in bodies that are inflammable. It may even be advanced, that theſe principles are of no uſe in the compoſition of inflammable bodies, but to detain and arreſt the particles of fire, which are the real and only matter of flame; and which only riſes into the air under this form, when the inflammable body having been expoſed to ſome external fire, has had its cells or veſiculæ broken up, and the contained fire ſet at liberty. It appears, therefore, to be the matter of flame that the artiſt loſes in decompounding inflammable bodies. *Mem. de l'Acad. An.* 1713.

† M. *Homberg*, indeed contends, that ſulphur or oil is fire it ſelf; or that there is no ſulphur beſide fire. In the analyſis of oils, ſays that author, their whole ſubſtance becomes reduced into a deal of aqueous

*Oil, its quality.*

is a body whoſe parts are eaſily diviſible, but withal are ſo branchy and tenacious, that 'tis with difficulty they let each other quite go: in which it differs from water, whoſe particles are equally diviſible, but not ſo branchy, nor catching ſo much on one another: as appears by pouring a little water on a poliſh'd mirror; for it may be wholly wiped off again, without the leaſt ſtain; whereas oil, and all oleaginous bodies, as ſpirit of wine, balms, reſins, &c. will ſtill leave ſome mark behind.

*Whence it becomes a fuel.*

Oil, then, feeds and ſuſtains fire by its particles being hook'd, and adhering to each other, ſo as to ſuſtain the impetus or effort of the fire, which tends to divide and diſperſe them; and to be put into a rotatory motion, rather than let one another go: Which rotation is ſo exceedingly ſwift, that no body except fire can follow it with equal velocity. In the mean time the fire, during this rotation, does ſo comminute the oil, and break off its branchy particles; that being no longer glutinous or adheſive, they cannot hang together; and conſequently become incapable any longer to ſuſtain the fire, and thus are diſſipated, and the fire extinguiſhed; unleſs freſh fuel be ſupplied from time to time.

*How affected by the fire.*

*How conſumed, and the fire extinguiſhed.*

*Whence ſome oils are more inflammable than others.*

This oil, the purer and more ſubtile it is, the eaſier it is inflamed, and the fitter for feeding fire: Thus alcohol, the moſt ſubtile of all oil, catches flame at the ſmalleſt fire; For it is to be obſerv'd, that no oil catches fire, till it firſt be heated; and that the coarſer and thicker the oil, the greater degree of heat muſt it conceive e'er it flame. And hence the reaſon why alcohol, ſo fine and ſubtile as it is, ſhould take fire ſo readily.

*The thinner oil is ſpread, the more readily it catches fire.*

The larger ſurface this oil is ſpread into, the ſooner it takes fire; as is evident in certain bodies which catch, and nouriſh the ſmalleſt ſpark: For charcoal is nothing but earth thinly ſpread over with oil; or, it is oil it ſelf, ſtretch'd over thin plates of earth, and thus extended to an infinite ſuperficies; the water, volatile oil, and ſalt, being all firſt carried off: as appears from the very method of making charcoal. Thus, if you apply a paper to the fire, it firſt expels its watery part, in form of ſmoke: then yields a ſtench, and lets go its more volatile oils: then it grows brown; and at length, when nothing but the earth and oil remain, black. The oil being now ſpread into thin lamellæ, in form of a blackiſh ſoot.

queous matter, ſome inſipid earth, and a little ſalt, partly volatile and partly fixed; the real principle ſulphur, which connected theſe ſeveral ingredients together, to make an oil, being loſt in the operation. The ſame befalls the ſulphur, in all bodies whatever, that undergo a rigorous analyſis; ſo that we have no poſitive way of arriving at the knowledge of its nature by the decompounding of mixt bodies: hence he was led to examine it, by making artificial mixts or compoſitions. And the reſult, he aſſures us, of a great number of operations of this kind, give him plain indications, that 'tis fire is the principle ſulphur, and that this is the only active matter in all bodies.

To ſupport this opinion, he endeavours to ſhew that fire, or the matter of light, is always in motion and action; and that this matter may be introduced into the other principles, change their figure and augment their weight and bulk, and connect 'em together, ſo as to produce all the mixts which fall under our obſervation. *Mem. de l'Acad. An.* 1705.

There

There is no the body feeds a ſparkling fire like charcoal; nor any body that catches a ſpark ſo readily: not ſulphur it ſelf. And hence, to render gunpowder the more eaſily inflammable, the fineſt charcoal duſt is added to the other ingredients, nitre and ſulphur. *Coal its quality*

Now, coal may be either made of the parts of animals, or vegetables; by only burning 'em to a blackneſs, and then extinguiſhing the fire: or, by making 'em undergo the greateſt degree of fire poſſible, in a cloſe veſſel. Thoſe chiefly uſed for a ready ſuſception of fire, are made of linnen cloth burnt to a blackneſs, and then immediately extinguiſhed; or of ſmall wood, particularly the branches of beech, burnt in like manner, and then pulverized: either of which catch the ſmalleſt ſpark of fire. *How made.* *Kinds thereof.*

1°, The fineſt, and ſubtleſt ſort of coal, is that made of paper, burnt to its utmoſt blackneſs, and then extinguiſh'd. This will catch the feebleſt ſpark.

2°, Linnen burnt, and extinguiſhed in the ſame manner, affords a pure coal, which very eaſily takes fire.

3°, Soot, which is nothing but oil it ſelf ſticking to the chimneys, readily burns; as plainly appears from conflagrations, which frequently begin in foul chimneys, from a ſingle ſpark of fire.

## *Which Bodies are Pabula, or Fuel of Fire.*

1°, ALL vegetables, without exception, afford a food for fire. *Jul. Cæſar*, indeed, and the elder *Pliny*, relate of the larch-tree, that it will not burn; but this is directly falſe, the tree abounding very much in oil. *All vegetables combuſtible.*

But the drier, and more ponderous vegetables are, the more laſting fire do they afford; as containing the more, and the purer oil than thoſe lighter, &c. And hence, the more oleaginous trees, which yield balm, pitch, &c. are uſed to be call'd *tædæ*, torches. If, then, the oil be ſpent, either thro' time, the air, worms, or the like, and the wood turn'd carious, it becomes unfit for burning. So alſo, if a vegetable be deſpoiled of its oil by diſtillation, coction, &c. it will never burn. But add ſome of this oil to a body before no ways inflammable, *e. gr.* to mere aſhes, and they readily take fire. Green wood is uſually held incombuſtible; and yet if it ſtay in the fire long enough to have its aqueous particles evaporated, it burns better than dry. The reaſon is, that in the uſual drying, and withering, not the water only, but ſome parts alſo of the oil are exhaled.

While a vegetable is burning, the fire not only moves the oil, but alſo agitates and drives, in a ſort of vortex, all the branchy parts in the vegetable: and hence its effect becomes the greater, and the deſtruction it makes more conſiderable. But it preys on the oil in a more eſpecial manner, by reaſon the tenacity of its particles make it a kind of focus. And hence the flame, burning bodies put forth, is not fire, or oil alone: for firſt, after the body is kindled, ſmoke ariſes, which, with the increaſe of fire, at length turns to flame. And ſmoke, in its paſſage up the chimney, leaves ſoot behind, which by diſtillation, yields a volatile ſalt, an inflammable ſpirit, earth, and two ſorts of oil; which ſhews, that the flame did not conſiſt of oil alone. And hence, *Fire agitates other parts of the vegetable beſide the oil.* *Its effect increaſed thereby.*

fire does not act merely by its own matter, but by thoſe ſpicula, and pieces of bodies, which it whirls round, and at length darts forth.

*Charcoal, a fuel.* The 2d pabulum of fire, is *charcoal*, prepared from vegetables; and all other coal prepared of the bones of animals which have oil in 'em, and are capable of turning black by burning. For, ſuch as do not become black in the fire, it is to be obſerved, inſtead of feeding, do really ſuffocate, and put out fire. *How prepared.* The manner of preparing charcoal is as follows. A quantity of any kind of green wood being heap'd up into a pile, with a little dry intermix'd, to make it kindle; and the whole cover'd externally with a coat of turf; fire is ſet to the ſame: when the whole heap is found ſufficiently ignited, they extinguiſh it again, by caſting in earth, and ſhutting out the air. By this means the whole heap is converted into black coal; whereof, that is moſt priz'd by the chemiſts which is made of beech: next, that of oak.

*Its poiſonous quality.* There appears to be ſomething poiſonous in theſe coals; for when kindled, they exhale a vapour, which if it be kept up, and confined in a cloſe place, cauſes vomiting, makes a man reel, and at length ſuffocates and kills him. The nature of this poiſon is perfectly unknown: *Helmont* calls it *gas ſylveſtre*.

Yet, is this a very commodious fuel; as it maintains the fire pure, and makes it eaſily governed.

*Turf.* 3°, *Turf*, whereof there are two kinds: the firſt, a glebe, pared from off heathy grounds, in ſhape of a parallelopiped; which may be reduced to the vegetable kind. The ſecond is dug underground, in a kind of fenny places, called *moſſes*: *Peat.* In peat-moſſes, there is a ſtratum ſome foot deep call'd *black-peat*, which being dug up with proper ſpades, and dried in the ſun, affords a fuel. *Its nature and principles.* It conſiſts of a fat, muddy, blackiſh earth, and ſeems to have a ſhare of ſulphur: and the ſulphur always contains bitumen, which is a ſort of neutral between ſulphur, and vegetable oil. The baſis, then, is an earthy matter, which contains foſſil ſalts: but for the reſt, it is of the vegetable claſs. The greateſt quantity of ſulphur is in that kind which yields ruddy aſhes not unlike *crocus martis*: the ſteam or ſmoke hereof is plainly ſulphurous, and tinges the countenances of perſons ſitting by it with a paleneſs like that of death. But that ſort which yields white aſhes, is the beſt.

*Its Origin.* As to the hiſtory of turf, or peat: by the pieces of putrified wood, frequently dug up along with 'em, and by the hiſtories remaining of this country, which repreſent it as anciently cover'd with woods; 'tis more than probable the places where turf are now found, were formerly woods, or foreſts; which ſhedding their leaves, and at length the trees themſelves tumbling, they became cover'd over with moſs, and thus, in proceſs of time, ſunk to their preſent depth †.

*Dutch turf its peculiar qualities.* The *Dutch* turf have this peculiar to 'em, that when thoroughly fired, they yield no ſmoke, but bear the fire with great firmneſs for ſome hours; when, at length, they fall to aſhes. For this reaſon, Mr. *Boyle* us'd to procure 'em, for his chemical experiments, from *Holland*. But their ſmoke, when but half lighted, is extremely noxious; and eſpecially in a cloſe place:

† An account of a peat-moſs form'd exactly in this manner, in *Scotland*, is given us by the Earl of *Cromarty*, in the *Philoſoph. Tranſact.* N°. 330.

insomuch,

insomuch, that it will suffocate an animal inclosed therein, without any pain or perception thereof.

4°, To these must be added *fossil* or *pit-coal*, dug out of pits or mines, in form of a heavy, black shining glebe; seeming to be a species of semi-metal or pyrites: it contains a large quantity of sulphur, which yet is different from the common sulphur, in that it has less of the acid, and therefore does not suffocate so soon. It feeds a flame so long as it remains black; but no longer: the flame bearing a near resemblance to that which nitre gives. The more close and compact these coals, the more vehemently they burn; they are supposed to have somewhat of a metallic nature in 'em, by reason they make such considerable alterations in bodies *. *Pit, or sea-coal.*

To this class likewise belong common sulphurs, bitumens, asphaltes, amber, naphta, petrol, agat, &c. which are a purer sort of fossil coal, and burn accordingly; they contain an acid spirit good against the plague, but pernicious to the breast.

5°, The *fat* of all animals, which burns in the fire: and the oil of fishes, as whales, &c. used to feed lamps. *Fat.*

Hither, likewise may be referr'd the dung of animals, which feed on herbs; which, dried in the sun, takes fire, and flames. These dungs, particularly that of cows, are burnt as the common fuel in some of the northern countries; but their smoke is hurtful, and extremely fetid. *Dung,*

6°, We may add, the several productions which chemistry furnishes from oils. Such is alcohol, the last effect of the chemists fire, which burns quite away, without any fume, or leaving any fæces. Camphor, petroleum, &c. do yield a fume. *Divers chemical substances.*

Now, as the pabulum of fire differs, the effects chemistry produces by it, are found to differ.

Thus, the fire of alcohol is the purest of all we know of, and is not capable of being heightened: the next are the oils of vegetables, which, the purer they are, the purer fire do they afford. *Fire different as its fuel is more or less pure.*

But 'tis impossible perfectly to purify an oil, or draw all that is heterogeneous out of it: there will, at least, a share of water perpetually remain, which is perfectly incombustible. But in alcohol there is neither salt nor earth, nor water; and accordingly it is the only perfectly inflammable matter in the whole universe. The next are oils distill'd *per vesicam*: for in boiling and shaking in the water, they lose their salt and earth, and become so much the purer, as the distillation is the oftener repeated.

* "The smoke of pit-coal being very "offensive, and other inconveniences at-"tending its use; a way has been found "to *char* and reduce it into coherent mas-"ses, of a proper size. 'Tis true it is sold "almost as dear as charcoal; yet those who "consume large quantities, find it near "twice as cheap, because it lasts much "longer, and gives a heat far more in-"tense. It would therefore be a very "useful thing in chemistry, to be able to "char coals, without the use of those pots "to which their present price is owing. "In *Holland* they have, likewise, a way of "charring peat, a kind of turf, which "might serve for fuel in chemical ope-"rations, tho' the manner of charring be "not yet known in several countries, "where, perhaps, peat might be found. *Boyle, Useful. of Exper. Philosoph.*

1°, The pureſt of all fires, then, is that collected from the ſun, which always remains immutably the ſame, and needs no pabulum to ſuſtain it.

2°, Next to this, we rank the pure flame of alcohol.

3°, Then, the fire procured from diſtill'd oils, well purified.

4°, Charcoal yields a tolerably pure flame, being purg'd of its water, and ſalt, and nothing but oil and earth left.

5°, Turf.

6°, The moſt impure of all is pit-coal.

### *The Effect of Fire different, as the Fire is of a different kind.*

*Diverſity of the effects of fire.* ALL theſe things are to be well known, and diſtinguiſh'd by the chemiſt; the ſucceſs of any experiment, depending very much on the diverſity of fire: for tho' all fire, in it ſelf, be perfectly ſimilar, and conſiſt of homogeneous parts, yet, the ſame individual fire being retained ſucceſſively in ſeveral pabulums, will have different effects; in as much as it acts by different mediums. So that tho' fire admit of no diverſity, conſidered as fire; yet it does, conſider'd as to the bodies it is inherent in. Even reaſon would tell us, that the effect muſt be different, if the operation be performed with fire of alcohol, from what it would be with vegetable turf. Mr. *Boyle*, in his treatiſe of the unforeſeen *failure of certain experiments*, concludes, that a great number of experiments, ſucceſsfully executed by ſome, have failed in the hands of others, merely from their uſing a different kind of fire. *Differences of ſmoak.* Thus wood, burnt in a naked fire, yields a ſmoke, which collected in a cloſe place, does a man no harm; unleſs, perhaps, it may offend his eyes: but if the coals be extinguiſhed under water, or a weight of ſtones, and then kindled again, their ſmoke is certain death, ſo that the ſame fire, of the ſame matter, in the ſame quantity, and the ſame place, makes different changes in the ſame objects. So an animal being incloſed in the half exhauſted receiver of an air-pump, if a quantity of the ſmoke of turfs be thrown in, it will ſoon be killed; but not with a like quantity of the ſmoke of wood.

*Blowing the fire.* Nay, the very manner of blowing a fire, makes an alteration in its effects. Thus, we have it from *Acoſta, Lib.* IV. *c.* 5. that the ſilver, from the mines of *Peru*, cannot be fuſed by a fire blown with bellows, but only by fire blown with a wind raiſed by the fall of a cataract. In order to this, they lay conduit-pipes from the tops of rocks, thro' which the water deſcending, agitates the air, and thus raiſes a conſtant wind, which is taken up by certain tubes diſpoſed for the purpoſe, and thus directed to the fire, which, by this artifice, readily melts the metals. And 'twas, probably, on ſome ſuch like account, that the gold, brought ſome years ago from *Portugal* into *England* and *Holland*, could not be melted in either of thoſe places, and yet in *France* was managed eaſily enough.

*Caſting water on it.* Water thrown plentifully upon fire, extinguiſhes the ſame; as compreſſing the oils, and hindering their rotatory motion. But if the water be thrown

thrown on ſparingly, the fire, in that caſe, overcoming the reſiſtance, breaks out with the more vehemence ||.

Air has a very great effect in the varying of fire: Thus, the heavier the air is, the more violently fire burns; and the lighter, the leſs: *in vacuo* it ſcarce burns at all, unleſs ſome way collected, either by being reflected or refracted. *Air, how it affects fire.*

When the atmoſphere is lighteſt, and the barometer ſtands the loweſt, then is the action of fire the weakeſt; and yet even then it is much greater than *in vacuo*. This diverſity, in reſpect of the ambient air, is particularly obſerved in the fuſing of metals; it being known, that at one time they will run much ſooner, and with leſs fire, than at another. Yet is not air the ſoul of fire, as *Centivoglio*; nor the pabulum of fire, as other philoſophers; nor any way conducive to the production thereof, as the generality of people imagine. And as to what is urg'd, that upon removing the air, the fire immediately periſhes; it is not univerſally true †; as appears from the obſervation of Dr. *Slare* and others, who find that fire may be produced *in vacuo*, by mixing the ſpirit of nitre with an aromatic oil *. Add, that phoſphorus ſtill burns *in vacuo*; and that the more they take away the air from *Weight of the atmoſphere.* *Fire producible without air.* *Phoſphorus.*

|| In the experiment of the phoſphorus, we obſerve, that water acts on the fire contained in the phoſphorus; in that it keeps it in, and prevents its conſumption, and diſſipation. Hence, as ſoon as the water is taken away, the heat and ſmoke immediately confeſs that the fire is breaking out. Add, that air it ſelf does alſo ſeem, in ſome meaſure, to keep in the fire contained in hot water; and hinder it from eſcaping ſo faſt as it does *in vacuo*: Thus, heating two equal veſſels of water equally, and then putting one of them in a receiver; as you exhauſt the air, the water will boil vehemently, and ſoon become barely lukewarm; while the other remaining in the open air, has neither boiled nor loſt any ſenſible part of its heat. Something like this is obſerved in ſhining wood; for ſome wood having rotted in the ground, ſhall ſhine very briſkly when taken out; the fire having been kept in by the contiguous earth: but in a day or two's continuance in the air, it ſpends all its light, and ceaſes to ſhine. 'Tis hard to ſay how fire ſhould thus be confined by ambient, looſe, porous bodies; or by what action ſuch bodies ſhould produce this effect: preſſure, one would imagine, ſhould be altogether inadequate, ſince it has been ſhewn that fire by its extreme ſubtility, can readily penetrate thro' all, evn the moſt ſolid bodies. *s'Graveſand*, *ibid.*

† The truth is, in ſome caſes, the preſence of air is neceſſary for the production of light, or preſervation of fire: as appears from the burning thoſe bodies which go out when the air is taken away; thus a lighted candle being put in a receiver, and the air exhauſted, the candle is immediately extinguiſhed: nor will the ordinary attrition of a flint and ſteel produce any ſpark of light *in vacuo*. On the contrary, on ſome occaſions the abſence of the air is neceſſary to light: as will be ſhewn hereafter. Laſtly, in other caſes, the light which was before ſeen in the air, becomes augmented upon taking away the air: as we ſee in the lucid lines drawn by phoſphorus. *s'Graveſand*, *ibid.*

* "For the ſake of thoſe who think the "attrition of contiguous air neceſſary to "produce a manifeſt heat, we placed ſome "hard black pitch in a baſon, at a con"venient diſtance under water, and caſt "the ſun's rays on it with a burning glaſs, "in ſuch manner, that, notwithſtanding "the refraction they ſuffer'd in paſſing "thro' the water; the focus falling on the "pitch, would produce ſometimes bub"bles, ſometimes ſmoke, and quickly "communicate a degree of heat, able to "melt it, if not alſo to make it boil. *Boyle*, *Mech. Orig. of Heat*, &c.

it, the brighter ſtill it ſhines. Beſide, that fire muſt be very copious in the regions about the ſun, where no body will expect to find air *.

*How air contributes to fire.* All the uſe of air, then, in our vulgar fire, is to make a kind of *fornax* or vault around it, and thereby reſtrain and keep in the oily particles, and prevent their flying off too haſtily. Hence, upon a total removal, or even a diminution of the preſſure of the air, that fire goes out: and hence it is, that the ſame portion of air ſhall not always be able to maintain the ſame fire; in that, air being rarified by heat, its preſſure becomes diminiſhed. This preſſion, and repreſſion, is continued ſo long, till the pabulum be broke ſmall enough for it to paſs thro' the pores of the air, and ſo fly away. *How fire goes out.* When this happens, we ſay the fire is ſpent, *i. e.* the combuſtible part of the fuel is diffuſed thro' the pores of the air; and the fire, of conſequence, turn'd looſe and vague again.

Air, therefore, acts no otherwiſe on fire, than as it confines, and keeps in the pabulum: And hence, the heavier the air, the fiercer the fire, and *vice verſa*. *Bellows, their effect.* And thus we ſee why bellows vibrate the fire, and increaſe its flame: for new air being thus forcibly thrown in, and the atmoſphere, by this means, coming to preſs nearer and cloſer, drives the combuſtible matter into leſs compaſs, and ſo lays it more obviouſly expoſed to the fire.

*Culinary fire its nature and phænomena.* And hence we ſee what our culinary fire is; *viz.* a congeries of the infinitely minute particles of elementary fire, forcibly thrown on a matter capable of liquifying by fire: which agitating and whirling round the oily particles of the fuel, divides and attenuates 'em; the agitation, withal, being ſo ſwift, that nothing but fire can keep pace with 'em; ſo that a collection, or continual acceſſion of fire, is hereby made. By this agitation, the hamous parts of the oil are gradually broke off, and thus the whole, at length, are rendered volatile; the vault of circumambient air, all the while compreſſing the ſaid particles with its own weight, which is equal to 32 cubic feet of water, or 29 inches of quickſilver, and thus retaining and repelling 'em, and collecting them about the place. And if this preſſure of the air be increaſed by any art, as by blowing with bellows, &c. the fire will be the greater.

If one of the above-mentioned circumſtances be wanting, the fire muſt go out: Thus, if the vault be wanting, there will be no triture; or, if it be too much increaſed, then the particles of oil being incumber'd, will become unfit for the briſk rotatory motion neceſſary to ſuſtain fire.

* "We took a piſtol, and having firmly "ty'd it to a ſtick almoſt as long as the "cavity of the receiver, we prim'd it with "dry gun-powder; then cocking it, we "faſtened the trigger to one end of a "ſtring, the other being faſtened to "the key in the cover of our receiver: "this done, we conveyed the whole apparatus into the veſſel, which being "cloſed up, and emptied after the uſual "manner, we turn'd the key in the cover, "and thereby ſhortning the ſtring, pull'd "the trigger, and obſerv'd, that the force "of the ſpring of the lock, was not ſenſibly abated by the abſence of the air; for "the cock falling with its uſual violence, "ſtruck as many, and as conſpicuous "ſparks of fire, as, for ought we could "perceive, it did in the open air. Upon "often repeating this experiment, we "could not perceive, but that the ſparks "of fire moved upwards, downwards, and "ſideways, as when out of the receiver." *Boyle, Phyſ. Mech. Exper. on Air.*

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Fire itfelf, we know, naturally rarefies the adjoining air; and repels, or drives it off, efpecially when any flame arifes; and thus makes a fort of *vacuum*, in the middle whereof is the fire and fuel. But action and reaction being equal, the more the fire impels the ambient air, the more does the air repel the fire: And thus is the attrition increas'd. So long, therefore, as there are oily parts remaining in the fuel, *i. e.* parts not comminuted or fubtilized enough to be thrown off, fo long the fire remains.

The greatnefs or fmallnefs of the fire, therefore, depends on the greater or lefs quantity thereof collected into one place or *focus*. In effect, we can fcarce imagine it poffible to increafe or diminifh any of the properties or the motion of fire: So that thefe muft be look'd on as out of the queftion.

Fire, thus collected, and thus fuftain'd by fuel, after it has done burning, leaves two kinds of matter behind it: 1°, afhes; and, 2°, fmoke. *Relicks of fire.*

Afhes are the fixed falts and earth of the fuel; and fmoke the volatile oil and water thereof. *Afhes.*

Smoke, pafs'd thro' the fire again, catches flame, and may thus be burnt or confumed quite away. *Smoke.*

It is obferved, that grofs bodies, when they yield their utmoft flame, afford both fmoke and afhes: when the flame is more moderate, the fuel, withal, being fuppofed well ignited, they only afford a very light fmoke; and when the flame is dwindled to a very fmall degree, they yield nothing but afhes. The fmoke is only fuch parts as cannot be diffolved in the fire, by reafon the fire has not yet attain'd a fufficient velocity; and hence it appears chiefly when the fire is firft lighted; and difappears again, when that has arrived at its pitch. Hence, alfo, if the fire be fufficiently fierce, when new fuel is thrown on, no new fmoke fhall arife; there being force of fire fufficient to diffolve it. Add, that the degree of fire is precifely according to the quantity of the fmoke; and the greater the fmoke is toward the beginning, the greater will the fire be, when it has attain'd to its velocity.

## *Direction of Fire.*

IT being already fhewn, that fire is the principal inftrument in chemiftry, it naturally follows, that its force is to be directed according to the intention of the operation. Now, the force of fire depends on the greater or lefs quantity thereof, collected in the fame place: for we hardly conceive it poffible to increafe or diminifh its motion, and make any alteration in that refpect. *Fire, how to be ufed in chemiftry.*

The whole art of chemiftry, then, confifts in collecting and directing fire to a degree fuitable to the divers occafions: For it is evident, at firft fight, that the degree of fire neceffary to fufe metals, is by no means proper to produce fpirit of wine.

We are indebted to the mathematicians for a method of eftimating fire, and of raifing and keeping it up to any degree at pleafure: This is done by means of the thermometer, the ufe whereof the ancients were unacquainted with. *How eftimated.*

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*Four degrees of fire.* The chemists usually reckon four degrees of fire; the three former whereof may be measured geometrically, by the thermometer: but the last is too violent for the thermometer to endure; so that we are here obliged to have recourse to another kind of register.

## *The various Degrees of Fire.*

*1°, That of a healthy man.* THE *first degree* is that equal to the warmth of a healthy body. This is determined by applying a thermometer to the person's mouth, (which is to be shut) and holding it there till the heat of the body be communicated thereto: Then, noting the degree, on the scale; the fire, in the furnace, is to be rais'd till it bring the spirit in the thermometer to the same degree. *Or a brooding hen.* This degree is also had, by applying the thermometer under a hen brooding over her eggs; so that some, by keeping the fire constantly to this degree, have hatch'd chickens out of eggs without any incubation. *Its use.* By this fire, all digestions, easy separations, solutions, gentle distillations, fermentations, and putrefactions are effected. For this reason it is said to be the digestive fire, or that which separates into homogeneous parts.

'Tis this which makes all things live and grow. This fire was taken notice of by *Hippocrates*, who observes, that bread and life are effected by a gentle fire.

*2°, That of a person in a fever, or a hot sun.* The *second degree* is that which affects the body of a sound person with a sense of pain, but without destroying the parts: Such is the heat of a feverish person, or that of a summer's sun, which scorches, inflames, and blisters the skin. This is a Mean between the heat of the first degree, and the third, which is that of boiling water; and therefore is easily determined by the thermometer.

*Its use.* This degree serves to make solutions and separations of the harder and heavier bodies, which the former is not equal to; as also to make fixations of some others, as mercury, by a gradual introducing of fire into the same: It makes the serum of the blood, or the white of an egg to coalesce; and thereby causes deadly inflammations. But digestions, fermentations, and putrefactions cannot be effected hereby.

*3°, That of boiling water.* The *third degree* is that of boiling water, which destroys the parts of animal bodies, produces mortifications, and death. This degree is perfectly stable, and permanent; nor is there any increasing thereof by any art. As soon as water has attain'd the degree of boiling, provided it be pure, it is not capable of conceiving any further heat; tho' an hundred times the fire were applied; as was first discover'd, by help of the thermometer, by Monf. *Amontons* *.

*Its use.* This degree of fire serves, in many cases, to separate, attenuate, and fix; and is used in other operations, where the former degrees are too weak.

* But different liquors under the same state are very differently hot: Thus, the heat of boiling water is scarce one fourth of that of boiling oil of vitriol; the latter raising the spirit in the thermometer to 540 or even 560 degrees; and the former only to 130. And yet the heat of boiling mercury exceeds them all by many degrees: Heat beyond this, is scarce measurable, (in regard it bursts the thermometer) excepting by the fusion of the different metals. *Boerhaave Cod. Impres.*

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The fourth degree is that which destroys all things, except metals; which, however, it fuses. And hence this degree is ascertain'd from the fusion of metals; for the thermometer cannot measure it, as not being able to bear such a force of fire, without perishing itself. As the degree of boiling water cannot be heighten'd, so neither can that of melted metals: for as soon as they begin to run, they have already conceived the utmost degree of heat they are capable of. In other respects, however, this degree is very indeterminate; inasmuch as different metals require different degrees of fire to fuse them. But these different, or subordinate degrees, we have no way yet of measuring precisely. *4°, Fuses metals.*

This degree serves in a great number of operations, particularly about metals; where the other three are too slack; and is the utmost degree known in any of the preceding ages. And as the former degrees are determined by the thermometer; so is this by the melting of iron or copper, which, of all others, are the hardest of fusion †. *Its use.*

But, to these four, a fifth degree has lately been added, which not only liquifies, but even volatilizes all metals; making them fly off in fumes. In the year 1690, M. *Tschirnhausen*, a *German*, invented a sort of burning-glasses, in whose *foci* nothing would remain fix'd, but even gold itself evaporate: And this is the last and highest degree of fire yet discover'd. *Olympic fire.*

Beside the five above-mentioned grand degrees of fire; there are a great number of other intermediate ones; which are easily known, and determin'd.

## *Of changing the Degree of Fire.*

THERE are five principal ways of varying the degree of fire. *Fire various according to the weight of the pabulum.*

1°, By the *different weight of the fuel*, or *pabulum*; the rule whereof is this, that the heavier the fuel, *cæteris paribus*, the more intense the fire. Thus, spirit of wine affords a weaker, gentler, and less destructive flame, than oil of turpentine; and this, again, than pitch or resin.

Spirit of wine only burns in its surface: Whence, the amplitude or extent of surface being given, the degree of fire it will raise, is easily found. Nor will this degree at all vary in equal surfaces, unless there be a difference in the density or lightness of the fire: So that the flame of spirit of wine may be kept to the same degree for years together; excepting for what alteration shall accrue from changes of the atmosphere.

After the fire of this spirit, we have gentle ones from all light, porous bodies, as hairs, feathers, spongy woods, &c. The last and utmost is that of metals, which imbibe so much the greater fire, as they make the greater resistance thereto.

2°, According to the *quantity of the fuel*: It being a rule, that the greater the quantity of fuel, *cæteris paribus*, the stronger the fire. Thus, *The quantity of fuel.*

† The four chemical degrees of fire are sometimes also taken from the different states of the human body, and estimated by their effect thereon: In this view, the first degree is that of a healthy person; the second, that of a feverish person: the third, that of a part inflamed; *e. gr.* by hot water: the fourth, that of boiling water.

a larger quantity of coals contain more fire than a lefs; inafmuch as the former collects more than the latter.

*According to the diftances of the fire.* 3°, According *to the diftance* of the fire from the object, in this proportion; that the greater or lefs the diftance of the fire from the object, the greater or lefs is its heat in refpect of that object; and this, according to the *Englifh* philofophers, in the ratio of the fquares of the diftances. Thus, if fire be one foot diftant from a body; and then removed to two feet: its action in the latter cafe will only be one fourth of that in the former. So, if removed three feet, it will be diminifhed nine times; if to four, fixteen times, *&c.*

But we have made feveral experiments to this purpofe; in all which the rule has been found to fail. The reafon of the failure is this, that the intenfenefs of heat does not depend altogether on the quantity of the fire, as the rule fuppofes; but alfo on the nearnefs of the fiery corpufcles to each other, which makes them act with a new force: as has already been obferv'd.

Thus, if you have two little fluctuating fires, their force will be found confiderably greater when join'd together, than when at a diftance from each other: For, in fuch cafe, they do not only act as two fires, *i. e.* with double the force of either; but as they affift, and increafe each other's force by a fort of attraction which is between them. And for this attraction, no rule or canon was ever affign'd.

*The quantity of air.* 4°, According to the *quantity of air* blown into the fire; the rule whereof is, that the greater the wind, provided it be not fuch as may break the aerial vault incumbent on the fire; the greater, *cæteris paribus*, is the fire. For, by violent blowing, the combuftible particles are put into the quicker motion: and by this means a great attrition enfues, and confequently a greater quantity of fire is collected. The fire, therefore, muft be the brisker; but, at the fame time, the *pabulum* confumed the fooner.

*The denfity of the medium.* 5°, According to the *folidity of the medium*, or body interpofed between the fire and the object; after this rate, that, the more folid the intermediate body is, the greater heat, *cæteris paribus*, does it receive from the fire, and communicate to the object. Thus, a vapour-bath communicates a lefs degree of heat to the body to be diftill'd, than a water-bath; and this, lefs than a fand-bath; and this laft, lefs than a bath prepared with fteel-filings. For all bodies, expofed to the fame fire, conceive heat in proportion to their feveral fpecific gravities. And hence, if a piece of metal, or ftone, or fand, be put in water, and both be fet to the fire; by that time the water is barely warm, the metal or ftone will be paft touching. And thus it is, that keys, in the pockets of perfons fitting by the fire, are frequently found very hot, while yet their clothes are but little the warmer.

If it be ask'd why this does not hold in mercury, a body much heavier than all ftones or metals, except gold; and yet not fufceptible of near their degree of heat? We anfwer, that it is of fo fluxile and volatile a nature, as not to ftand the action of a ftrong fire long enough to conceive its utmoft heat; but flies off in fumes upon the firft approach of fire: And hence the in-

intenſeneſs of the heat of a bath of iron or ſteel-filings; that matter being very heavy, and at the ſame time not eaſy of fuſion.

On the footing of this rule of the denſity of mediums, the gentleſt fire we can make, is in air. For, if you have two equal cylinders, the one full of water, and the other of air, and expoſe them both to the fire; that with the air will not heat near ſo faſt as that with water.

Next to air comes ſpirit of wine, which is lighter than water.

And hence the invention of *chemical baths*, which are divided into air, vapour, and water-baths; the effects whereof may be increaſed to boiling water. *Baths.*

From what has been ſaid, the manner of managing fire will be eaſily conceiv'd.

The higheſt degree of fire, is that which calcines all bodies; which can only be had from the ſun: as in M. *Villette*'s mirrour, *&c.*

The leaſt degree we have known, is that obſerved about fifteen years ago, by the thermometer, in *Ireland*; the ſpirit riſing ſcarce ſo high as one diviſion.

Now, fire, acting in ſuch various degrees, produces various operations: For the ſame which gives life to a man frozen with cold, is able to kill one in a due ſtate of health.

It is a celebrated queſtion, long controverted among the chemiſts, Whether fire, when applied to bodies, does only ſeparate their parts; or whether it does not likewiſe change them? Mr. *Boyle* has labour'd the point in his *Sceptical Chymiſt*, and ſhewn beyond contradiction, that fire changes and compounds, as well as ſeparates. And this ſingle conſideration one would think ſufficient to evince it; *viz.* that in acting upon ſeveral bodies, it inſinuates itſelf into them, and fixes in them; ſo as eaſily to compoſe one body therewith. Thus lead remaining over the fire, after fuſion, increaſes in weight: And thus ſalt of tartar, tho' by the firſt fuſion it loſe of its weight, yet coming afterwards to be calcined, it gains; and this the more, the more it is calcined. Add, that *phoſphorus* muſt needs borrow its ſhining parts from the particles of fire fixed therein during the diſtillation: for it cannot be ſuppoſed to have pre-exiſted ſo in the human body. Nor are the productions of fire ſimple, as moſt have imagined: Thus, that celebrated one ſalt, is reducible into ſpirit and earth; and oil into water and earth. *Fire changes bodies.*

This fire is not an univerſal diſſolvent, but a comparative one only. For, *Fire does not diſſolve all ſorts of bodies.*

1°, If gold and ſilver, melted together in the ſame veſſel, remain in a continued fluor for months, they will be never the nearer to a ſeparation. *Nor ſeparate all.*

2°, What it does diſſolve, is not reduced thereby into its laſt elements or corpuſcles.

3°, It mixes abundance of things which before were not mix'd; *e. gr.* mercury and ſulphur, into cinnabar. *Mixes bodies.*

4°, It conjoins divers things: which are eaſily ſeparated again by other means; *e. gr.* gold and ſilver, which *aqua fortis* ſeparates. *Conjoins.*

5°, It unites ſome things, and ſeparates others, according to the degree it is in: Thus, it muſt be in a moderate degree to mix melted gold and ſilver; and in the higheſt, for mercury and ſulphur. *Unites, or ſeparates, according to circumſtances.*

Nay,

*Opposite effects from the same degree.*

Nay, and the same degree shall have opposite effects: Thus, a vehement fire shall render water, oils, salts, *&c.* volatile; and yet the same convert sand and a fixed alcaline salt, into glass, which is a body almost immutable by fire, air, and all other bodies.

*Different effects according to the manner of application.*

6°, It varies according to the application: Thus, it will not kindle sulphur in a close vessel, but with ease in the open air.

Fire, therefore, is no universal solvent: for it fixes, as well as volatilizes; unites as well as separates; compounds as well as analyzes: And further, fire is not a pure or sincere dissolvent; as it does not separate the parts, without making alterations in them. Thus, if you resolve wine into its principles, *viz.* oil, water, spirit, *&c.* and reunite or remix these principles again, you will by no means have the same body as before.

We cannot therefore say of any production of fire, that it existed in the body before——Consequently, the productions of fire are not simple.

Nor does fire render all things volatile: The *Adepti*, for instance, have found, that the first matter or basis of metals, *viz.* mercury, which by a vehement heat evaporates; if urged by a gentle equable one, as that of the first degree, long continued; becomes united or incorporated with its sulphur, into a fixed mass; which the second degree fixes yet further; the third further still; and the fourth only fuses *. Again, if you take a quantity of oaken-wood, slit it into thin shivers, and expose it for some years to the air, and then burn it; you will get no fixed salt from the same; and yet the same wood, burnt green and new, will afford a large quantity of fixed salt. So that, in the latter case, the fire seems to have fix'd the salts, which before were volatile.

Hence, according to the various degree of fire made use of, various productions arise.

## GENERAL COROLLARY.

BY this fire hitherto described, we are able to separate, or unite, these, or those bodies, and produce these, or those effects: But we cannot say of fire universally, that it burns, it unites, or it separates; for this would be contrary to experience: The utmost we can say, is, that a certain degree of fire, applied to a certain body, has this or that particular effect. The nature of the object, of the fire, and of the medium, are all necessary to be taken in, and consider'd: And yet, were we sure of all these, even then there are other particular circumstances enough to prevent our asserting any thing universally.

* "Common quick-silver, being duly "purified with iron and antimony, be-"comes more fluid and active than before; "and yet, putting this same mercury to "digest by a proper heat, we find, that, "without the addition of any other mat-"ter, it will gradually cease to flow, "and at length change into a fix'd pow-"der, which weighs more than the mer-"cury at first did; and which will even "bear to be kept red hot the space of "twenty-four hours. *Homberg. ibid.*

Of

# *Of* AIR.

WE now come to conſider *air*, which is the ſecond univerſal inſtrument of chemiſtry; there being no operation performed by fire, without the intervention of air: unleſs, perhaps, thoſe few done in the exhauſted receiver of an air-pump. *Air.*

By *air* we mean all that fluid expanded maſs of matter which ſurrounds our earth, in which we live, and walk; and which we are continually receiving and caſting out again, by reſpiration. *Defined.*

This maſs conſiſts of three different kinds of matter; *viz.* 1°, Of *fire*, which is an inſeparable concomitant of air, and is equally diffuſed thro' the ſame; 2°, Of *exhalations*, raiſed from all kinds of bodies; and 3°, Of a certain aerial matter, or *air* properly ſo called *. *Its conſtituent parts.*

Air, therefore, may be conſidered in two reſpects; either as it is an univerſal aſſemblage or chaos of all kinds of bodies, or as it is a body indued with its own proper qualities.

## *Fire in* AIR.

I. THAT there is fire contained in all air, is evident from what has been already ſhewn of fire's exiſting in all bodies, and all places: in effect, 'tis to this fire, that air ſeems to owe all its fluidity; and were that fire totally removed, it is more than probable the air would coaleſce into a ſolid body. For we find, by actual experiment, that the air condenſes, and contracts it ſelf ſo much the more, the leſs degree of warmth it has; and on the contrary, expands it ſelf the more, as the heat is greater. *Fire.* *The cauſe of the fluidity of air.*

Thus, in all the intermediate degrees, from animal warmth, to the utmoſt degree of cold art is able to produce, we conſtantly obſerve, the air to grow continually more and more contracted, denſer and heavier; and conſequently nearer to the nature of a ſolid: But the little degree of fire ſtill remaining, continues active, and thereby prevents a

* Not unlike to this, is that diviſion of Mr. *Boyle*: The atmoſpherical air that author conjectures to conſiſt of three different kinds of corpuſcles: the firſt, thoſe numberleſs particles which, in the form of vapours, or dry exhalations, aſcend from the earth, water, minerals, vegetables, animals, *&c.* in a word, whatever ſubſtances are elevated by the celeſtial, or ſubterraneal heat, and thence diffuſed into the Atmoſphere. The ſecond may be yet more ſubtile, and conſiſt of thoſe exceedingly minute atoms, the magnetical effluvia of the earth, with other innumerable particles ſent from the bodies of the celeſtial luminaries, and cauſing, by their impulſe, the idea of light in us. The third ſort is its characteriſtic and eſſential property, we mean permanently elaſtic parts. *Hiſtory of Air.*

total concretion: For there is ſtill fire remaining; and even the ſmalleſt fire will produce motion, which is inconſiſtent with firmneſs.

*As much fire in air as in ſpirit of wine.*

Air, therefore, is always warm, or has fire; which concluſion I had an opportunity laſt year of confirming, by a great number of experiments: in the courſe whereof, I made appear that the degree of fire in air is the ſame with that in alcohol of wine.

This fire, equably diſperſed thro' the atmoſphere, tho incapable of being totally ſeparated from the ſame, may yet be diminiſhed to any degree at pleaſure.

*Air varied by the varieties in the heavenly bodies.*

And ſince the air lies open to the influxes of the ſun and ſtars, it muſt be various, as it is variouſly affected thereby *.

Air, we have obſerved, is kept moving and fluid by means of the fire, and in proportion thereto: for no degree of fire remains conſtant, but is perpetually either increaſing or diminiſhing.

* Beſides the alterations in reſpect of heat and cold, drought and moiſture, to which our atmoſphere is liable from the heavenly bodies; very great philoſophers have ſuſpected that there may be other more immediate and ſpecific ones. Sir *I. Newton* ſuppoſes, that the vapour which makes the tail of comets, coming to be exceedingly rarified and agitated in their approach toward the ſun, may be driven and diffuſed thence thro' the heavenly ſpaces, and ſo come to be attracted by the ſeveral planets within whoſe ſpheres of activity it chances to be thrown. Thus mixing with their atmoſpheres, ſays he, it may afford them a freſh ſupply of water, to defray the continual expences thereof in vegetation, putrefaction, &c. He adds, that he ſuſpects the fineſt, pureſt, and beſt part of our air, that, in effect, whereby life is ſuſtained, to be principally derived from the Comets. *Phil. Nat. Princ. Math. l.* 3.

Mr. *Boyle* ſuggeſts, that even the ſun, and other celeſtial bodies, may have influences here below diſtinct from their heat and light; and that the ſubtile effluvia thereof, may reach as far as our atmoſphere, and mix therewith. Every planet, ſays he, has its own proper light, diſtinct from that of the others; which is either a bare quality, on which ſuppoſition its utmoſt uſe and deſign is only to illuminate: or elſe all light is attended with ſome peculiar virtue, or tincture; in which caſe every light muſt have its peculiar property, tincture and colour, its own ſpecific virtue and power; in which the planets all differ from each other. Thus, adds he, the ſun not only ſhines on all the planets, but, by his genial warmth, calls forth, excites, and raiſes the motions, properties, and powers, peculiar to them. Whence, according to the angle they make with that grand luminary, and the degree wherein they are enlightened, either by its direct or oblique rays, in a near or remote ſituation in reſpect of the earth; the effects of the powers, virtues, and tinctures proper to each, muſt be more or leſs perceived by us. *Hiſt. of Air.*

'—As the other planets, ſo alſo our earth, 'is not only enlightened, warmed, cheriſhed 'and made fruitful by the influence of the ſun; 'but it hath, moreover, its proper magnetical, 'planetary force, awakened, fermented, excited, 'and agitated thereby; which it ſends back 'with the reflected light of that luminary. By 'this means alſo, the ſeminal diſpoſitions, odours and ferments, lodged in particular 'regions and parts hereof, emit and diffuſe 'thro' the air either their kindly and grateful, 'or malignant, congealing, and putrefying qualities. Hence, tho the temper, diſpoſition, 'and general qualities of the air, may be aſſigned, according to the motions, influences, 'and aſpects of ſeveral ſuperior planets; yet the 'particular healthfulneſs and unhealthfulneſs of 'places; the bad diſpoſitions of the air, whether in the evenings, nights or mornings; in 'ſome places more than others; exceſſive 'moiſture, great winds, droughts, or ſeaſons 'peculiar to a country; ſhould chiefly be 'aſcribed to thoſe odours, vapours and exhalations, that by the action of the ſun, or 'other planets, are forced from their particular 'ſeats in the planets themſelves, into the open 'air.' *Id. Ibid.*

If,

If, now, this fire in the air be only acted on, or impelled in parallel lines, it remains insensible therein; as is evident in high mountains, where, tho the sun shines with all his vigour, yet the cold is extreme: but, if the fire be reflected, the air then grows sensibly warm. 'Tis not, therefore, the action of the sun that occasions warmth; but the reflection of the fire from solid bodies. And hence the warmth is usually the most felt in valleys.

The air, therefore, receives various degrees of fire; 1°, In respect of the sun, as he emits his rays, either obliquely, or perpendicularly. 2°, In respect of the earth, as it either absorbs the rays it receives, or reflects them.

'Tis this fire contained in air, that seems chiefly to move those foreign, grosser corpuscles wherewith the atmosphere is replenished by the exhalations sent from terrestrial bodies; as is found by those who travel the higher mountains, and who find their senses of smelling and tasting greatly diminished, and almost lost. Wine is there found as insipid as water: which, no doubt, is owing to a want of the due pression and application of the particles of the liquor to the papillæ of the tongue, *&c.* The like is observed in very severe winter weather, when the sense of tasting is always diminished proportionably to the degree of cold. *Effects of the fire in the atmosphere.*

## *Exhalations in* AIR, *which render it an universal chaos or conflux of all bodies.*

II. IN respect of *Exhalations*, air may be said to be a general collection of all kinds of bodies *: for there are none but what fire will render volatile, and disperse into air. Even salts, sulphurs, and stones; nay, and gold it self, tho the heaviest and most fixed of bodies, we have already observed, are convertible into vapour by a large burning-glass, and carried on high. *Vapours and exhalations,*

Those floating particles, thus raised from terrestrial bodies, are moved and agitated by the fiery particles divers ways; whence arise tremors and concussions in the air; which being communicated to bodies that lie in their way, produce innumerable effects †. So, in places where great fires, combustions, conflagrations, *&c.* are; volatile salts of all *Acted on by the fire.*

* This Mr. *Boyle* long ago noted: 'Our atmosphere, *says he*, is a compound or aggregate of effluvia from such different bodies, as, tho they all agree in constituting, by their minuteness and various motions, one great mass of fluid matter, yet, perhaps, there is not a more heterogeneous body in the world.' *Suspic. of Hid. Qual. in the Air.*

† 'Tho the chief of the heterogeneous effluvia, that endue the air with secret qualities, may, probably, proceed from beneath the surface of the earth, and from the celestial bodies; yet at some times, and in some places, the air may derive multitudes of efficacious particles from its own operations; acting as a fluid substance upon the vast number and variety of bodies, which are immediately exposed to it.' *Boyle, Hid. Qual. in Air.*

ſorts are copiouſly diſcharged into the air, there agitated by the fire, and diffuſed thro' the whole atmoſphere. And hence ariſe various actions on bodies : thus, near copper and iron furnaces, forges, *&c.* innumerable effects are produced by the fire's agitating the groſſer corpuſcles in the air, impelling one againſt another, breaking, comminuting, *&c.*

Of the matters thus raiſed into the atmoſphere; thoſe coming from fluid bodies are properly called *Vapours*; and thoſe from ſolid or dry ones, *Exhalations*.

Of theſe, the variety is almoſt infinite ; and there is ſcarce any body in nature that can be excepted from the number : for gold ſticks cloſe to ſulphur in the mines, and is raiſed with it. And, with the other metals, a like inflammable, arſenical ſulphur is uſually found intermixed ; which being agitated by fire, readily carries them off: And the other foſſils, as coals, marcaſites, *&c.* riſe with ſtill more eaſe. So alſo, all ſorts of waters, ſpirits, oils, acid, alkaline, inflammable, compound, *&c.* muſt be ever floating, in abundance, in the air ; as follows from the continual diſtillations, *&c.* made thereof. Earths, we add, are many of them eaſily volatilized, and made to float in air ; for all, even the ſubtileſt, oils, yield a conſiderable quantity of earth at the ſecond diſtillation ; ſo that the earth muſt float with the oil. What then can be excepted? Nothing.

The cauſe of this volatility, and aſcent, is the fire ; without which, all things would fall immediately down toward the centre of the earth, and remain in eternal reſt. Thus, if the air be full of vapours, and cold ſucceed ; thoſe vapours before diſperſed, are congregated and condenſed into clouds ; and thus fall back again in form of water. So when water boils, we ſee a vapour aſcend ; and no body doubts but that 'tis fire is the cauſe of that elevation, as well as of the other motions of the water : whether this fire be originally in the air, or whether it be determined thither from the celeſtial bodies, or whether it come from ſubterraneous places.

Air, then, replete with ſuch a variety of exhalations, may be looked on as a general chaos. And,

*The matter of infinite numbers of animals of all ſorts in the air.*

1°, The *parts of all animals* are found therein : for any animal, being expoſed to the air, will exhale, or diſſipate ; even tho the wind does not blow ; leaving the bones alone ; which yet, in a few years, will themſelves exhale. So that what, before, made the animal, *v.g.* a man, a horſe, dog, or the like, is now all in the air, both fluid parts and ſolid *.

2°, The

* And here the excrementitious parts muſt make no ſmall figure : My Lord *Sandwich*, and two Gentlemen of his retinue, aſſured Mr. *Boyle*, ' That the common report, as ' to there being no neceſſary houſes at ' *Madrid*, was true ; and that tho they always make a jakes of their ſtreets over ' night, 'tis not eaſily diſcoverable by the ſcent ' the next morning. *Madrid*, however, his ' Lordſhip ſaid, had a more offenſive ſcent ' than any city he knew : but they all agreed, ' that the place wherein the ambaſſador's family ' conſtantly,

2°, The *parts of all vegetables* are alſo there: for, take any plant, and putrify it; and it all readily becomes volatile; except the earth, which in time evaporates like the reſt. *Of all ſorts of vegetables.*

And, 3°, the *parts of all foſſils*: for all ſalts, for inſtance, are carried off by a vehement fire, into the air †; and the ſame holds of ſulphurs, ſtones, *&c.* Nay, and gold it ſelf, as has been divers times obſerved, is readily ſent, by a large burning-glaſs, the ſame way. *Of all ſorts of foſſils.*

The atmoſphere, therefore, may be looked on as an univerſal receptacle, or chemical veſſel, wherein all the bodies in nature actually float.

And hence we are enabled to account for many of the effects of air: About mines, deep caverns, *&c.* there are frequently found copious fumes, and exhalations continually iſſuing out, which in a moment's time deſtroy any animal that comes within their reach; ſo much as the very inſects; flies themſelves not eſcaping. Theſe places the antients called *Gehennæ*, *Speluncæ*, and *Averni*, from α and ορνος, a *bird*; intimating thereby that birds could not fly over them but dropped down dead. Such, in *Italy*, is the *Grotta dei Cani*; a dog held over which, but a ſingle moment, expires; tho, if inſtantly thrown into cold water, he recovers, and comes to life again. On the contrary, in a certain place in *Poland*, where the inhabitants are ſaid to attain to an hundred years of age, the air is always clear, and the neighbouring lakes and ſprings afford a ſalutary vapour *. Add, that in *Sicily* there are divers places now inhabited, which were antiently perfectly uninhabitable. *Hence various effects of air.* *Averni.* *Grotta dei Cani.*

'conſtantly made water, had no ſcent of urine; 'and that they frequently obſerved, both the dogs 'and cats, which lay dead in the ſtreets, afforded 'no offenſive ſmell.' *Id. Hiſt. of Air.*

† 'One principal ſort of theſe effluvia in 'the atmoſphere, I take to be *ſaline*, which 'float variouſly among the reſt in that vaſt 'ocean; for they ſeem not to be equally 'mixed therein, but are to be found of different kinds, in different quantities and places, 'at different ſeaſons. The arguments which 'ſhew that ſubterraneous effluvia in general, 'aſcend plentifully into the air, prove the ſame 'of ſaline ones in particular; ſince it has been 'demonſtrated, that immenſe quantities of common, nitrous, aluminous, vitriolic, and perhaps other ſalts, riſe among the various exhalations of the terraqueous globe. Nor is 'this the only means whereby the air may be 'impregnated with ſaline particles; for the 'action of the ſun upon the ſuperficial parts 'of the earth and ſea, will, alone, ſupply that 'fluid with ſwarms of them. And the quantity hereof may be greatly increaſed in ſeveral places by ſuch vulcano's as have open 'vents, by the ſmoke of the common culinary fires, *&c.*' *Boyle's Hiſt. of Air.*

The air of ſome places may, beſides the ſimple ſalts already mentioned, contain ſome compound ones; it being ſhewn, that particular ſaline ſpirits may meet and join together therein; as alſo that two liquors may be ſo ordered, that one of them ſhall never, of it ſelf, afford any thing in a dry form, yet its ſpirituous effluvia meeting with thoſe of the æther, produce a dry, volatile and ſaline body; which the mixture of the liquors themſelves would not. *Ibid.*

* In an expreſs treatiſe on *the wholeſomeneſs and unwholeſomeneſs of the air*, Mr. *Boyle* makes appear, that it depends principally on the impregnation the air receives from ſubterraneal effluvia, a cauſe generally overlook'd by phyſicians; of which he diſtinguiſhes divers kinds, *viz. ordinary*, which are almoſt conſtantly ſending up; *extraordinary*, which riſe but at certain times. Theſe, again, if they come at ſtated ſeaſons, he calls *periodical*; if uncertainly, *fortuitous*, or irregular.

In the general, tho the wholesomeneſs of the air in ſome places may be chiefly due to the wholeſome expirations of ſubterraneal bodies; yet is the air depraved in far more places than it is improved, by being impregnated with mineral expirations. Indeed, among the minerals known to us, there are many more noxious than wholeſome; and the power of the former to do miſchief, is more efficacious than of the latter to do good; as we may gueſs by the ſmall benefit men receive in point of health, by the effluvia of any mineral, or other known foſſil, in compariſon of the great and ſudden damage that is often done by the expirations of orpiment, ſandarack, and white arſenic.

Among the various ſorts of particles wherewith the atmoſphere is replete, ſome, he ſhews, may be ſo ſmall and ſolid, or ſo conveniently ſhaped, as to enter many of the numerous orifices of the minute glandules of the skin, or at other pores thereof. Thus, tho neither paper, nor a bladder, be pervious to the elaſtic parts of the air; yet may either of them be eaſily penetrated by other corpuſcles of the atmoſphere: and that excellent author has prepared a dry body, which being incloſed in either, would, without wetting or diſcolouring, or any way ſenſibly altering them, paſs in a trice thro' the pores thereof, in ſuch plenty as to exert a maniſeſt operation on bodies placed at ſome diſtance therefrom.

This is confirmed from the ſudden check almoſt every ſummer given to the plague at *Grand Cairo*: for, ſince morbific cauſes operate more effectually than curative ones, it ſeems more than probable, that exhalations aſcending from under ground, may produce peſtilential fevers, and the plague it ſelf; ſince the corpuſcles which impregnate the *Egyptian* air upon the ſwelling of the *Nile*, put a ſpeedy ſtop not only to the contagion, but to the malignity of the plague, aſſiſted even by the ſummer's heat, which there is exceſſive.

'Tis very probable, that moſt of the diſeaſes, which even moſt phyſicians call *new*, are cauſed, either principally or ſecondarily, by ſubterraneal ſteams.

Indeed there may be noxious minerals in a country, without being often able to produce peſtilences: they may lie in beds ſo deep, that even a ſmall earthquake ſhall not reach ſo far downwards, as to affect them; tho a more violent ſhock may. And hence we may account for the plague's raging in ſome parts of *Africa*, once in thirty, or once in a hundred years; ſince there may be periodical paroxyſms, or grand and vehement commotions, in ſubterraneal parts, tho not yet obſerved in them. A late judicious *French* hiſtorian records, that a very pernicious diſeaſe, of the nature of a cholic, reigned in *France* every tenth year, for ſeventy years together.

*Mezeray* relates, 'That the great plague 'which happened in *France* in the year 1346, 'and which was ſo contagious, that ſcarce a 'village, or even an houſe, eſcaped uninfected; 'began, two years before, in the kingdom of '*Cathay*, by a vapour moſt horribly fetid, and 'breaking out of the earth, like a kind of ſubterraneal fire; which conſumed and devoured 'above two hundred leagues of that country, 'even to the very trees and ſtones; and in'fected the air in a wonderful manner.' He adds, 'that from *Cathay* it paſſed into *Aſia* 'and *Greece*, thence into *Afric*, and afterwards 'into *Europe*, which it ranſacked throughout.' *Hiſt. de France*.

And not only plagues, but moſt new, contagious, and epidemical diſeaſes, Mr. *Boyle* takes to ariſe from ſubterraneous cauſes. He inſtances a great cold, which, in one day or two, invaded multitudes in the ſame city, with violent and fatal ſymptoms; when yet, he could ſee no room to judge, that the bare coldneſs of the air could ſo ſuddenly produce a diſeaſe ſo epidemical and hurtful; and it appeared more probable that the cauſe came from under ground, becauſe it began with a very troubleſome fog.

Peculiar kinds of venomous exhalations, 'tis probable, may ſometimes be emitted; eſpecially after earthquakes; and thus occaſion mortal diſeaſes in animals of one kind, and not of another; and in this or that place, and not elſewhere. *Fernelius* gives us an acconnt of a plague or murrain in 1514, which invaded none but cats. *Dionyſius Halicarnaſſæus* mentions a plague which attacked none but maids: and that which raged in the time of *Gentilis* killed ſcarce any women; and very few but luſty men. *Boterus* mentions another great plague which aſſaulted none but the younger ſort; and we have inſtances of the ſame kind of a later ſtanding. *Cardan* ſpeaks of a plague at *Baſil*, with which the *Switzers*, and not the *Italians*, *Germans*, or *French*, were infected: and *Joh. Utenhovius* takes notice of a cruel plague at *Copenhagen*; which, tho it raged among the *Danes*, ſpared the *Germans*, *Dutch*, and *Engliſh*, who went with all freedom, and without the leaſt danger, to the houſes of the infected.

From

2

From these exhalations, the air in different places becomes very different *: thus where there are mines of sulphur, as in *Carniola*, † *Campania*, &c. the air is frequently very pernicious. Add, that the effluvia of animals have their effect on the air; as is evident in the case of contagious diseases, plagues, murrains, and other mortalities which are spread by the air. And the like is observed of plants ||.

*Whence the difference of air in different places,*

The air, again, becomes different according to the season of the year: for in winter, the earth, being bound up with cold, scarce sends any exhalations at all; and yet the subterraneal fire is all the while agitating, and preparing particles of all kinds, to be set at liberty from their subterranean holds, by the warmth of the ensuing spring, and discharged into the common receiver, the air. And hence the difference between the vernal and autumnal air; for if you sow the same seed in the same ground, in spring and in autumn, different plants will arise; even tho the degree of heat were the same in both cases. And for this reason it is, that many chemists, to get the greater quantity of spirit from corns, use to steep them in rain-water gathered in the spring.

*Indifferent seasons.*

* In places abounding with *Marcasites*, says Mr. *Boyle*, 'there is a fretting vitriolic salt 'largely dispersed thro' the air, which has been 'observed to rot the hangings of rooms, and 'other furniture; and to lie upon the surface 'of the ground in a whitish efflorescence, after 'the sun had heated the moist and blackish 'mould wherein it lay.' *Boyl's Hist. of Air.*

Besides these saline substances of a determinate species, there are possibly, at certain times and places, other corpuscles in the air of a saline nature, but not reducible to any particular kind, which we therefore call *anonymous.* We have observed in old glass windows, belonging to high and antient buildings, some panes corroded, as if they had been worm-eaten; which seems to argue, that sharp and fretting particles had been carried thither by winds, whereto that glass was exposed; tho none of the salts before-mentioned have the faculty of corroding common glass. *Id. ibid.*

† 'The many saline effluvia that rise with 'the other subterraneous steams, cannot, all 'of them, be well suppos'd of a simple and 'uncompounded nature. A very intelligent 'acquaintance of mine, who visited a vul'cano in *America*, told me, that before he 'came near enough to the fire, to be very sen'sible of its heat, the skin of his face was so 'corroded, and the colour of his hair changed, 'by the exhalations, as to prevent his nearer 'approach thereto.' *Id. Hist. of Air.*

'At *Fashlun* in *Sweden*, noted for one of 'the best copper mines of that kingdom, the 'mineral exhalations affect the air so, that 'their silver coin is frequently discoloured, and 'sometimes turned black thereby; tho close 'tied up in several purses, and locked up in 'strong chests. The same effluvia manifestly 'affect brass, and to such a degree, that there 'is no possibility of keeping their utensils of 'this kind tolerably clean.' *Id. ibid.*

'A virtuoso, who possessed a piece of ground 'wherein ran several veins of different metals 'and minerals, told me he had frequently seen 'pillars, as it were, of fumes, ascending thence 'like smoke; some whereof had no scent, some 'an ill one, and some again a good one; tho 'the latter happened but seldom.' *Id. ibid.*

|| 'A very ingenious physician told me, he 'learned upon the island *Ternate*, that the '*Dutch* having agreed with the king, to fell 'almost all the clove-trees that grew there, in 'order to raise the value of their spice; such 'a change in the temper of the air happened 'thereupon, as shewed the exhalations which 'the blossoms, when dried, afford the cloves 'to be very wholesome; for soon after these 'fragrant trees were cut down, the whole 'island became exceedingly sickly; which my 'relator imputed to the corrosive and noxious 'steams of a vulcano there, the ill effects 'whereof were formerly prevented by the aro'matic effluvia of those spicy blossoms.' *Boyle ubi supra.*

And

And thus we ſee the reaſon why in ſome countries, where the winter is ſeverer than ordinary, the ſpring is more than ordinary fruitful: for here the exhalations, being pent up a long time, are diſcharged in the greater quantity, when the ſun makes 'em a paſſage; whereas, under a feebler cold, the efflux would have been continual, and conſequently no great ſtock reſerved for the next occaſion.

From the entrance of the ſpring till autumn, the evaporation is conſtant: but then it begins to fail; and in the winter ceaſes, to lay up freſh matter for the coming ſeaſon.

*Whence ſevere winters produce plentiful harveſts.*

Thus it is, that froſty winters, by congealing the waters, and covering the earth with a cruſt, and thus impriſoning the exhalations; make a fruitful ſummer: for this is no check upon the ſubterraneous fire, which ſtill continues its office; the froſt never reaching above two foot under ground. So that if you dig to that depth, in winter, the earth will always be found to ſmoak very plentifully.

This vaporous matter, then, being at length received into the atmoſphere, is returned again in form of rain, the ſure fore-runner of a chearful crop.

When the cold is very conſiderable in ſummer, thunder and lightning ariſe; which contribute to the looſening and ſetting at liberty the remaining vapours, deep incloſed under ground: and when the ſun's force begins to fail, they muſt of courſe return in ſhowers, &c.

While the ſun is returning from the winter's ſolſtice to the ſummer's, his rays darting on us ſtill more and more perpendicularly, the matter of the earth is more and more relaxed, ſoftned, and putrified; till he arrives at the tropic, where his heat and force is at the height. And then, with the force of a chemical agent, he converts or reſolves every thing near the ſurface of the earth into its principles, water, ſulphur, ſalt and oil, which are eaſily raiſed into the atmoſphere.

As the ſun retires, the cold ſucceeds: and thus, the diverſity of ſeaſons of the year, depends on a change in the face of the cruſt of the earth, the preſence of the air, and the ſun's courſe *.

And hence we conceive the nature of meteors, which are all either collections of ſuch vapours, and exhalations, or diſperſions thereof. Collections of vapours make clouds; which being further and further condenſed, turn to ſnow, rain, or hail. The ſubtiler oils, we have noted, are always

* Mr. *Boyle* ſuggeſts farther variations in the air, accruing from the diverſity of heat and cold: 'The air, he obſerves, being a fluid as 'well as water, and impregnated with ſalts of 'different kinds, 'tis not improbable, that what 'happens in water, impregnated with ſuch ſalts, 'may alſo happen in the air. Two proper 'quantities, of different ſalts, being diſſolved 'in hot water, they floated undiſtinguiſhably 'therein, and retained a capacity to act in 'conjunction upon ſeveral occaſions; yet when 'the liquor became cold, the ſaline particles 'of one kind being no longer agitated by a 'due degree of heat, ſhot into cryſtals; and 'loſing their fluidity and motion, viſibly ſeparated themſelves from the other, which ſtill 'continued fluid in the liquor, and capable of 'acting ſeparately. Hence it ſeems probable, 'that coldneſs and heat may, for a time, greatly alter the qualities of the air, with regard 'to the bodies and health of mankind. *Ibid.*

rising into the air: now two clouds partly formed of such oils, happening to meet and mix; by the attrition, the oil frequently takes fire; and hence thunder, lightning †, and other fiery phænomena: which may be further promoted by the disposition of the clouds to favour the excitation.

*Whence thunder.*

And hence arise great and sudden alterations in the air; insomuch, that it shall now be intensely hot, and raise the spirit, perhaps, to eighty eight degrees: and yet, after a clap of thunder, with a shower, it shall fall again, in a few minutes, no less than twenty or thirty degrees.

Ice may be, and is, formed even in the heavens, from the intense cold that frequently prevails there; and the suns ray's passing duly thro' ice, have their force considerably increased; as we see in burning-glasses made of ice. And hence may our degree of heat be liable to be greatly heightened; as, accordingly, we observe, that when our atmosphere is replete with clouds, provided they be not gross enough to intercept the rays; our heat is then most intense and sultry. 'Tis known that none of these clouds are above an *English* mile high*; and hence on very high mountains, the warmth is inconsiderable. In effect, our heat depends more on the circumstances of the clouds, and the bodies beneath them, than on all that is above them; taking sun, moon, stars, and all. 'Tis impossible therefore to pronounce what the degree of heat will be in any given place, at any time; even tho we knew ever so well the places and positions of the sun and planets, with respect to us: since it depends so much on other variable things, no ways capable of being ascertained.

*On what the heat of our weather chiefly depends.*

These meteors too have their effects on the air: thus thunder is known to produce new fermentations of liquors, &c.

*Effects of thunder.*

To these may be added another cause, which varies the condition of the air, *viz. earthquakes:* for, the fire perpetually burning under ground, has its spiracles or vent-holes; which happening by any means to be stopped up, it produces violent tremors and shakes, till it has opened it self a new passage, where none was before. And if the matter discharged hereat ||, be

*Earthquakes.*

† Effects of the like kind have even been observed, where so many circumstances have not concurred: A *Neopolitan* nobleman acquainted Mr. *Boyle*, that during his stay at a country-house near *Naples*, he used frequently to ride upon a very sulphureous soil, where, if his horse trod pretty hard, a great crackling noise would arise, which, to a stranger, might have seem'd surprizing; and dusty sulphureous fumes would be raised, which seemed ready to take fire, as sometimes he thought they actually did; and having caused some turfs to be cut out of this ground, and laid together in a heap, he could, in the night-time, sometimes observe the effluvia thence arising to kindle in the air.

* 'An excellent astronomer of my acquaintance, who frequently took the height of the clouds, very rarely found any even of the white ones, in fair weather, to be more than three quarters of a mile, and seldom above half a mile, from the surface of the earth.' *Boyle's Hist. of Air.*

|| ''Tis well known, that about mount *Vesuvius*, the exhalations are of so saline and sulphureous a nature, that they adhere to the orifices of its vents, like flowers of sulphur. And I have a stone brought me from the same vulcano, with a white salt in its cavities; which, upon examination, proved a-kin to sal-ammoniac, and easily soluble in water; one part being very volatile, and the other remaining

be of any poisonous quality; the air, being replete therewith, becomes of course unwholesome, contagious, and frequently deadly.

*Effluvia of mines.*

This eruption of pestilential vapours, is no where more apparent than at the *Cape of Good-hope*; where the mines, as soon as opened, emit such horrible fumes from the arsenic, which is a constant attendant on gold, that no animal can live near them; so that endless treasures may there remain for ever useless *.

The same cause, here, likewise operates; in that by such succussions of the earth, conversions are made of dry land into lakes or seas; of sound wholesome places, into rotten putrid ones. So also, where ships formerly sailed, we now plough a dry and solid soil.

*Difference of air at different degrees of depth.*

The heighth or depth of air, makes a yet further considerable alteration therein: for the exhalations are few of them able to ascend above the tops of mountains †; as appears from those plagues where the inhabitants

'maining somewhat fixt; whence it seems 'very probable, that salt was compounded in 'the bowels of the vulcano; great quantities 'thereof having, as I am evidently informed, 'been cast up in the fiery eruptions; and 'therefore, since I found it sublimable, it 'might, by that means, be largely dispersed 'thro' the air.' *Boyle, ubi supra.*

'Eighteen years ago, a terrible noise began at 'the port of *Santorini*; reaching even to *Chio*, 'distant therefrom above two hundred miles; 'which was supposed to proceed from the *Venetians* fighting with the *Turks*: but at length it 'was found to be caused by a fire underneath 'the port above-mentioned, which there cast 'up, from the bottom of the sea, quantities 'of pumice-stones, with a force and report 'as great as if they had been severally discharged from a cannon. The air of *Santorini* was by this means so infected, that abundance of people were killed, and many lost 'their sight thereby; tho they recovered it in 'a few days afterwards. This infection spread 'it self as far as the preceding noise had 'reached; for even at *Chio* and *Smyrna*, all 'the coin was changed red, both that in the 'pocket and that locked up in chests; and the 'same happened to the silver chalices in the 'churches. The infection, however, vanished 'in a few days time, and the silver recover'd 'its native colour.' *Voyage de Levant.*

In the year 1660, in the kingdom of *Naples*, after an eruption of *Vesuvius*, strange crosses appeared on linen that had lain open to the air. They were extremely numerous in several parts of the kingdom of *Naples*; and the jesuit, who sent the relation to *Kircher*, says, that he himself found thirty in one altar-cloth; fifteen upon the shift-sleeve of a woman; and eight in a boy's band. Their colour and magnitude were also very unequal, and their figure different; they would not wash out with simple water, but required soap. These were found, not only upon linen garments exposed to the air, but upon some of those that were kept up in locked chests.

* What effect the neighbourhood of mines have, appears from Mr. *Boyle*: A famous chemist, who lived in a country abounding with mines of vitriol, assured him, that he had found the oaks growing over them to be remarkably more solid and heavy, than those trees elsewhere are; upon which Mr. *Boyle* observes, that the parts of some minerals are capable of insinuating themselves very plentifully into the pores of growing vegetables, without being really subdued by what the philosophers call the concocting faculty of the plant; but instead of being assimilated by the vegetable, retain their own mineral nature; and upon the recess, or evaporation of the juice that served them for a vehicle, sometimes discover themselves to the naked eye. He adds, that he has seen a piece of a vine, that grew not far from *Paris*, which being broken, a multitude of the internal pores of the root, and a part of the trunk also, appeared to be stuffed with corpuscles of a marcasitical nature, as was plain by their colour, their shining lustre, and their weight. *Causes of wholesomeness*, &c. *of the air.*

† 'On one side of the mountains of *Bavaria* 'tis winter, and on the other summer, 'at the same time; so that while this side is 'parched with heat, that lies buried in snow.' *Balbin. Hist. Bohem.* p. 55.

of one ſide of a mountain have all periſhed, yet thoſe on the other ſide all the while remained in perfect health. Now ſtill, the lower the place, the cloſer, denſer, and heavier the air; till, at length, you arrive at a depth where fire goes out: ſo that the miners, who go very deep, to remedy this inconvenience, are forced to have recourſe to an artificial wind; raiſed by the fall of waters, to do the office of the other air *.

The air may likewiſe undergo ſome alterations by means of its motion: thus a briſk wind leſſens the preſſure of the incumbent atmoſphere; by which means the ſubterraneous air may be enabled to raiſe the cruſt of earth, or occaſion a ſhuddering thereof. And hence that obſervation of Mr. *Hauksby*, that the barometer ſinks very notably, when the wind is raiſed, or the air agitated, about the ſame. *Effect of winds.*

Now, conſidering the air as ſuch a chaos or aſſemblage of all kinds of bodies, and a chaos ſo extremely liable to change; it muſt needs have a great influence on chemical operations, and occaſion notable alterations in the ſame: thus there is ſcarce any procuring of oil of ſulphur, *per campanam*, in a clear air; its parts being then ſo extremely ready to fly off: but in a thick cloudy air, it yields oil in abundance. And thus ſalts melt the eaſieſt in a cloudy air; and when melted, act the moſt forcibly: and all ſeparations ſucceed the beſt in ſuch weather. *Effect of air on chemical operations.* *Oil of ſulphur, &c. when beſt procured.*

The ſucceſs of chemical operations, therefore, has a near dependence on the air; and the ſame operation performed at different places, or times, when the air is differently inpregnated, *&c.* may well have a different effect. Thus if ſalt of tartar be expoſed to the air, in a place where any acid ſpirit, as vinegar, is floating in the air, as in the ſhops where vinegar is ſold; it will draw the vinegar to it ſelf, and by that means loſe its former qualities, and, of fixed, become volatile: but in places where there is no acid, it diſſolves into an extremely ſharp oil †. *Different effects of the ſame operation.*

And

* Nor muſt drought and moiſture be denied their ſhare in varying the ſtate of the atmoſphere: At *Guinea*, the heat, with the moiſture of the air, are ſaid to be ſo favourable to putrefaction, that the fineſt white ſugar ſhall ſometimes be full of maggots; and all their drugs, plaiſters, *&c.* quite loſe their virtue; and ſome of them grow verminous. 'Tis added, that in the iſland of *Jago*, they are obliged to expoſe their ſweetmeats to the heat of the ſun; and thereby exhale the moiſture they contracted in the night, which would otherwiſe have cauſed them to putrefy. *Boyle's Hiſt. of Air.*

The ſtring of a viol has been obſerved to increaſe in the acuteneſs of its tone, by almoſt half a note, either a little before, or in rainy weather; and the ſame obſerver has likewiſe found that putting falſe ſtrings in his pocket for frets, they have been found true when he came to uſe them. *Id. ibid.*

'If ſome *Egyptian* earth be taken up 'near the river, and carefully preſerved from 'the wet and waſte, 'twill be found, if duly 'examined by the ballance, neither to increaſe 'nor diminiſh its weight till the 17th of *June*; 'when it will begin to grow heavier, and 'continue to do ſo as the river fills; whence 'they certainly know the ſtate of the deluge, 'which doubtleſs proceeds from the moiſture 'of the air.' *Proſper. Alpinus, Joh. Varot*, &c. *p.* 69.

† The air of particular places, as about great towns, *&c.* Mr. *Boyle* obſerves may probably abound with volatile ſalts, of a contrary nature to acids. That places deep under the

And thus the experiments made of ſalts, at *London*, where the air is plentifully impregnated with ſulphur, exhaled from the ſea-coal, are very different from thoſe made on the ſame ſubjects in other parts of the kingdom, where wood, turf, *&c.* are the uſual fuel *.

*Effects of the various effluvia in the air, on chemical operations.*

Thoſe alterations in the air, wherewith our own bodies are found to be affected, affect chemical bodies, in a ſtill more ſenſible manner: hence, as the air, in the laboratories of the chemiſts, is ſometimes pregnant with acids, ſometimes with alcalies, and ſometimes with metallic fumes, their operations become ſtrangely diverſified.

And in general, the air, as it contains divers kinds of exhalations, has a wonderful effect towards promoting, ſtopping, or altering the actions of all bodies on each other; whence frequently ariſe very aſtoniſhing effects.

*Of the fumes of new wine.*

Thus, if pure, well-fermented wine, be carried into a place where the air is repleniſhed with the fumes of new wine then fermenting; it will begin to ferment afreſh. So we have ſeen ſalt of tartar ſwell, and as it were ferment, when carried into a place where ſpirits of nitre, vitriol, and ſea-ſalt, were preparing; *viz.* by the contiguity of the acid particles floating in the air.

*Plants in bloſſom, what effect they have.*

It is matter of common obſervation among brewers, diſtillers of geneva, and vinegar-makers, That at the time when thoſe plants uſe to be in flower, the reſpective juices ferment, and the operations ſucceed the beſt †.

*Whence metals contract ruſt.*

Metals expoſed to the air, when well impregnated with ſuch ſaline particles, ſoon corrode, and grow ruſty; but the ſame in an air void of ſuch particles, will remain a long time without damage: thus metalline inſtruments, and utenſils, contract ruſt much ſooner, and therefore need ſcouring much oftener, at *London*, where they are open to the acid or ſulphurous exhalations of immenſe quantities of ſea-coal, than

the ground may lodge ſuch ſalts, ſeems not unlikely, from the experiment of an acquaintance of mine, who cauſed to be dug up, at the depth of ſeveral yards below the ſurface of the earth, a large quantity of a certain kind of clay, abounding in minerals; whence he obtained, by ſimple diſtillation, a conſiderable parcel of ſpirit of ſalt, greatly reſembling thoſe of urine or harts-horn. *Hiſt. of Air.*

* In places where much wood is burnt, numerous particles of volatile ſalt may eaſily be diſperſed thro' the adjacent air; for wood-ſoot, which is only that ſmall part of the ſmoke which adheres to the chimney-ſides, affords a volatile, ſaline ſpirit in great plenty; and not readily, unleſs by the ſcent, diſtinguiſhable from that of urine or hartſhorn. Moreover, the putrefaction of animal ſubſtances, may ſupply the air with volatile ſalts, ſince ſome putrefied urine will, without diſtillation, afford ſaline and ſpirituous parts, which, by their ſcent, *&c.* diſcover themſelves to be volatile, even while ſwimming in their own large quantity of phlegm. And the like is obſervable in many vegetables. *Id. ibid.*

† 'Add, that ſtains cauſed by vegetable 'juices, are obſerved to be beſt taken out of 'linen at that time, when the ſeveral plants 'that afford them are in their prime. This 'one lady has experienced in new linen ſtained 'by the juice of quinces; and another in 'ſome diſcoloured by the juice of hops, which 'ſhe thinks makes the worſt of ſtains; but 'having tried in vain to fetch this out, ſhe 'locked up the linen in a cheſt, till the ſeaſon of hops came on, and then the ſpots 'vaniſhed of themſelves.' *Id. ibid.*

in

in other parts, where there is leſs of the acidity *. And fermentation, which is eaſily raiſed and carried on in a place free of ſulphur, is impracticable in places where ſulphurous exhalations abound.

Add, that the ſingular ſucceſs which the dyers of *Leyden* have, in dying wools of a ſcarlet colour, is, in all appearance, owing to no other cauſe, but the air which muſt be there impregnated with vitriolic, aluminous, and other ſaline exhalations, raiſed from the great quantities of thoſe ſalts which the dyers daily empty out of their veſſels into the waters of the city; for it is impoſſible the waters ſhould be charged therewith, without the air's becoming a partaker: and hence, the ſame means, the very ſame ingredients, applied at *Amſterdam*, and elſe where, have not the ſame effect †. *Effects of the air in dying.*

It remains to be obſerved, tho it comes here ſomewhat out of place, that the air is every where in continual motion: for, in the ſtilleſt ſeaſon, where there is no wind ſtirring, if you place your ſelf in a darkned room, which only receives the day in at a little hole, capable of admitting a ſingle ray; that ray dividing it ſelf, and illumining the whole length of the room, you will perceive every thing, all the external objects whoſe ſpecies are thus brought in, in motion; which can never be owing to our reſpiration: but to the external air which inſinuating itſelf thro' the chinks of the edifice, moves that on the inſide of the chamber. And hence the mercury in a very large, accurate barometer, is found to be continually vibrating, or leaping up and down, without ever remaining a moment quiet. *Air always in motion.*

This perpetual motion of air is owing to the fire, which acts there on the true or proper air, by means of its native elaſticity: but of this we ſhall treat anon; our buſineſs here is with air conſidered as a chaos.

* 'It does not appear that in-land countries abound conſiderably with corroſive ſalts; 'ſince the bars and caſements of windows 'will not thereby be greatly impaired by ruſt, 'after they have endured the weather for twenty 'years; whence I conjecture, that the kind 'of ſalts whereby that diſſolution is effected, 'proceeds from ſea-vapours, or thoſe raiſed 'by the burning of mineral coals. *Id. ibid.*

† Mr. *Boyle* propoſes a method of determining what the particular ſpecies of ſalt is that predominates in the air of any place, or at any time. This, he thinks, may be done by a ſort of magnets, or attractives, *i. e.* bodies fitted to detain and abſorb, or at leaſt likely to be affected by, the particular ſalts ſuppoſed chiefly to abound: For inſtance, if we ſuſpect the air to be impregnated with nitre, lime, or the like bodies which imbibe or retain ſuch a ſaltneſs; dyed cloths, or ſilks of ſuch particular colours, which fade or tarniſh with nitrous ſpirits, may be expoſed thereto: where vitriolic effluvia are ſuppoſed predominant, proper preparations of ſulphur may be ſuſpended, to try whether they will acquire a blackneſs: In other places, gueſſes may be made, by ſpreading on the clean ground white linen cloth, well freed from ſoap or lye, and obſerving, after it has lain a conſiderable time, what diſcolouration it has ſuffered, and what ſaltneſs it has imbibed; either from the aſcending ſteams, or falling dews.

Or, you may find ſome one body capable of being affected by ſeveral aerial ſalts, in ſuch different manners, as to diſcover which kind produced the reſpective changes. *Hiſt. of Air.*

The

The motion of the air, and consequently its force and effect, arise wholly from fire; and hence, the fire, by moving all the various kinds of particles which are in the air, performs infinite operations. In the extremest cold, the air scarce acts at all, but is contracted within itself; but when warmed, it expands again, and agitates other bodies: consequently, as the degrees of heat are infinite, so must the actions and effects of the air be. Add, that as this fire acts on all the corpuscles which are in the air, and these are infinite; 'tis evident all the actions thereof are indefinite.

## Air, *considered in it self, or that properly called* AIR.

*Proper air.* III. BESIDES the fire and exhalations contained in the circumambient atmosphere, there is a third matter, which is what we properly mean by *air* *.

To define the nature of air, would be extremely difficult; in as much as its intimate affections are unknown to us. All we know, is, 1°, That air is naturally an homogeneous similar body. 2°, Fluid. 3°, Heavy. *Its properties.* 4°, Elastic. 5°, That it rarifies by fire, and contracts by cold. 6°, That it is compressible by a weight laid thereon, and rises and restores it self upon a removal of the same. All which circumstances, should incline it to coalesce into a solid, were fire wanting.

*Structure.* Mr. *Boyle* conceives the air to be a congeries of minute flocculi, all springy, expansile, and contractile; and takes it to derive its elastic

* Some of the later authors divide air into *transient* or apparent, and *permanent* or real: for that all which appears to be air, does not continue such, is evident hence, that if an eolipile of water be sufficiently heated, and suffered to expel the particles of air by its aqueous vapour; this will afterwards be forcibly driven out in a large quantity, like the blast of a pair of bellows, and occasion a sharp, whistling noise against the edge of a knife conveniently held there: yet such a vapour, tho whilst the motion lasts it resembles air, soon loses that resemblance; especially in the cold; and returns, by condensation, to its original water.

Mr. *Boyle* gives us several experiments and methods for the production of air; taking the word *production* for the obtaining a sensible quantity of that fluid from bodies wherein it did not before appear either at all, or in so great plenty; tho perhaps some of his experiments may argue a new and real production of air in the stricter sense of the word. *Hist. of Air.*

'Among the several ways of producing air, 'the fittest for practice seem to be fermen- 'tation, corrosion, and the dissolution of bo- 'dies, by the boiling of water and other li- 'quors, by the mutual action of bodies upon 'one another, especially saline ones; and 'lastly, by analyzing and resolving certain sub- 'stances.' *Ibid.*

Sir *I. Newton* shews that gunpowder generates air; *i. e.* by explosion it goes off in a flaming smoke, or red-hot exhalation, consisting chiefly of the spirit of nitre rarified by the accension of the sulphur and charcoal, and driven off much after the manner of water out of an eolipyle; the volatile sulphur, at the same time, and the fixed body of nitre, joining with it, and increasing the effect. *Opticks, p.* 317.

'I have found that various, solid, and mi- 'neral bodies, unsuspected of elasticity, be- 'ing plunged in corrosive unelastical menstrua, 'will, upon a proper comminution of their 'parts, afford, in the conflict, a considerable 'quantity of permanently elastic air.' *Boyle, ubi supra.*

force

force from its ſtructure, or the form of theſe floccules; which he reſembles to fleeces of wool †.

Sir *I. Newton*, without concerning himſelf as to the figure of the particles of air, conſiders its effects alone; and theſe aerial particles, he obſerves, in approaching nearer each other, exert certain new powers whereby they mutually endeavour to recede, or fly from each other: ſo that the further they are a-part, the leſs does this force act; and the nearer, the ſtronger *. *Repelling force in their.*

Either hypotheſis may be ſufficient: but we add, that the former aſſumes, or takes the moſt for granted; ſince it ſuppoſes the air to be fleecy; whereas, in the latter, the particles of the air may be of any figure at pleaſure, provided they have but the *vis recedendi*. For our own parts, we confeſs we don't know what air is. *Fluidity of air.*

That air is a *body*, and *fluid*, no body will call in queſtion, after what has been ſhewn above. And hence it is always in motion, and always moving other bodies; and no ſurface of any liquor that is contiguous to air can be at reſt: which point we have proved more at length in our public lectures *de Aere*.

The *gravity* or heavineſs of the air is eaſily proved: for the elements of all bodies, are as heavy as the elements of gold; and the variety of bodies in point of weight, ariſes only from the particular ſurface which thoſe particles acquire, in the contexture. Thus, if you beat gold into *Gravity.*

† 'Various hypotheſes may be framed 'relating to the ſtructure of theſe particles of air. They might be reſembled 'to the ſprings of watches, coiled up and 'endeavouring to reſtore themſelves; to 'wools, which being compreſſed, have an 'elaſtic force; to ſlender wires, of different 'ſubſtances, conſiſtences, lengths and thickneſs; in greater curls or leſs; near to or remoter from each other, &c. yet all continuing ſpringy, expanſible and compreſſible. 'Laſtly, they may alſo be compared to the 'thin ſhavings of different kinds of wood, 'various in their lengths, breadth, and thickneſs.' *Boyle, ubi ſupra.*

* The inſtance of air and vapours, which ſeem to diſcover ſome ſuch repelling power, that illuſtrious author brings as an argument of the ſame powers being found in other bodies:—'The particles emitted or ſhaken off 'from bodies by heat or fermentation, *ſays he*, ſo ſoon as they are beyond the reach of the attraction of the body, recede from it, and alſo from one another, with great ſtrength; and keep at a diſtance; ſo, as 'ſometimes to take above a million of times 'more ſpace than they did before, in the 'form of a denſe body: which vaſt contraction and expanſion ſeems unintelligible, 'by feigning the particles of air to be ſpringy 'and ramous, or rolled up like hoops; or by 'any other means than a repulſive power.

'The particles of fluids which do not cohere too ſtrongly, and are of ſuch ſmallneſs as renders them moſt ſuſceptible of 'thoſe agitations which keep liquors in a 'fluor; are moſt eaſily ſeparated, and rarified 'into vapour; and, in the language of the 'chemiſts, are *volatile*: rarifying with an eaſy 'heat, and condenſing with cold. But thoſe 'which are groſſer, and ſo leſs ſuſceptible of 'agitation, cohere by a ſtronger attraction, 'and are not ſeparated without ſtronger heat, 'or perhaps not without fermentation; and 'theſe laſt are the bodies which chemiſts 'call *fixed*; which being rarified by fermentation, become true permanent air; thoſe 'particles receding from one another with 'the greateſt force, and being moſt difficultly 'brought together, which, upon contact, cohere moſt ſtrongly.

'And becauſe the particles of permanent 'air are groſſer, and ariſe from denſer ſubſtances than thoſe of vapours; thence it is 'that true air is more ponderous than vapour, and that a moiſt atmoſphere is lighter 'than a dry one.' *Opticks, p.* 371, 372.

very

very thin plates, or leaves, it will ſwim in water, or even air; ſo that it does by no means appear, that the laſt particles of air are more porous than thoſe of gold *.

*Uſe and effects of its preſſure.* Now, the weight of the whole incumbent air, is ſuch as enables it to ſuſtain mercury in the Torricellian tube to the height of 28 inches; and water to that of 32 feet. Air therefore, may be conſidered as an univerſal operculum, or cover, which by its weight, keeps all terreſtrial bodies down, and prevents their flying off. And hence, if this preſſure of the air be much diminiſhed in any place, a piece of earth may happen to be raiſed thereby, and thus an earth-quake be produced: for the air under ground, having, by this means, a leſs weight to ſuſtain, will expand itſelf; the conſequence of which muſt be a ſubverſion of the incumbent earth.

*In mixing bodies.* The air thus preſſing, and keeping things under, after the manner of an embolus; does, of conſequence, mix them with one another: as, in effect, there is no natural mixture made without air †.

*In determining one body to act on another.* 'Tis air, again, that determines the action of one body to another; for, to have one body act on another, 'tis neceſſary it be applied or preſſed againſt it. All the volatile bodies in the atmoſphere, may be conceived as fluids floating in another fluid; now, the lighter the fluid, wherein bodies ſwim, is, the deeper muſt the bodies deſcend: thus we find gold ſink to the bottom of water; and wood falls downright in air: on the contrary, the heavier the fluid, the more will the body emerge above water. And thus the fluid retains the ſeveral ſorts of bodies in their reſpective places.

*Menſtruum inactive in vacuo.* Now, we find, if a menſtruum be applied in vacuo, it has no effect. Thus vinegar does not prey on copper, or iron, in the exhauſted receiver; but as ſoon as the air is let in, it begins to act, and a calx or ruſt ſoon enſues. So, if you lay the point of a diamond on the ſurface of a poliſhed glaſs, it will not cut; but preſs it ſtrongly with the hand, and it has its effect. *Papin's digeſtor.* Thus in *Papin*'s digeſtor: a thick, ſtrong cylindrical veſſel being filled with water, or the like menſtruum; and the bones of ſome animal, *e.g.* an aged ox, included therein; and laſtly, the cover or lid firmly fixed and ſoldered over, ſo as neither water nor air

* This proof is *à priori*. But we have much more ſenſible demonſtrations of the thing from experiment: thus the hand, applied ſo as to cover the orifice of a receiver, upon working the air-pump, and thus withdrawing the ſubjacent air, ſoon feels the load; ſo, exhauſting the air from a thin, ſquare glaſs receiver, the preſſure of the incumbent air eaſily burſts it: again, two hollow ſegments of a ſphere, exactly fitting each other, being exhauſted of their air, and thus expoſed to the preſſure of the external air; will ſuſtain a force of 140 pounds; ſuppoſing their diameters 3 inches, ere they ſeparate. To ſay no more, the riſing of mercury in the barometer to the height of 28 inches, and of water in pumps, *&c.* to that of 32 feet, are inconteſtable proofs of the weight of the air. See the Writers of Hydroſtaticks, *Boyle*, *Wolfius*, *S'Graveſand*, &c.

† 'The particles whereof air conſiſts do 'not touch each other; their *vis repellens* 'keeps them a-part: and the force where-'with they endeavour to recede, increaſes in 'the ſame ratio wherein the diſtance of the 'particles is diminiſhed.' *S'Graveſand, ibid.*

air may eſcape: upon applying this to the fire, as the heated air comes to expand, it has a prodigious effect; grinding and diſſolving, in the ſpace of a few minutes, the firmeſt bones into a mere fluid; and this by the ſole preſſion of the air againſt the water, and bones.

But we have ſaid that the air is an *elaſtic* body: Now, elaſticity is a quality whereby a body yeilds to any external impreſſion, by contracting it ſelf into leſs compaſs; and upon removing or diminiſhing the impreſſive power, returns to its former ſpace or figure. By this quality it is, that air is diſtinguiſhed from all the other bodies in the atmoſphere; neither fire nor exhalations appearing to be elaſtic, at leaſt in any notable degree. *Elaſticity of the air.*

That there is ſuch a quality in the air, is evident from innumerable experiments. We ſhall only mention one: In the firſt invented thermometer, ſome air is included in a hollow ball; which, as the warmth or cold increaſes or diminiſhes, contracts or expands it ſelf; and by that means either drives the ſpirit lower, or lets it riſe higher. And to the ſame elaſtic power it is owing, that air incloſed in glaſs veſſels, at a time when it is much condenſed, frequently burſts the veſſels, when it afterwards comes to expand by a further degree of heat *. *Proved.*

This property is inſeparable from air: ſo that it was an overſight in Mr. *Hauksby* to conclude, that air might be compreſſed ſo long, till it loſt its elaſtic power, and became incapable of expanding it ſelf again: for this is never found, even tho air have been kept in continual forcible compreſſion the ſpace of many years. That air is elaſtic in all places, appears hence, that the air contained in a bladder, endeavours to expand it ſelf on the tops of the higheſt mountains, as much as with us. *An inſeparable property.*

This, further, is very wonderful in air; that it ſhould be capable of being extended, and contracted infinitely; for by all the experiments we have ſeen or heard of, it does not appear that there are any limits of its *No limits to the compreſſion and dilatation of the air.*

* 'The elaſticity of the air is as its denſity; for this laſt is inverſly as the ſpace taken up by the air, and therefore as the force compreſſing the air, which is equal to that by which the air endeavours to expand itſelf; but this force is its elaſticity.' *S'Graveſande's Elem. Phyſ.*

'The air is loaded by the weight of the whole atmoſphere, preſſing every way, according to the nature of a liquid; the force it exerts does no way depend upon the elaſticity; becauſe, whether you ſuppoſe elaſticity or not, that force which ariſes from the weight of the atmoſphere, and is equal to it, can no way be changed: but, as the air is elaſtic, it is reduced to ſuch a ſpace by the weight of the atmoſphere, as that the elaſticity, which re-acts againſt the compreſſing weight, is equal to that weight. But the elaſticity increaſes and diminiſhes as the diſtance of the particles diminiſhes or increaſes, and it is no matter whether the air be retained in a certain ſpace by the weight of the atmoſphere, or any other way; for in either caſe, it will endeavour to expand it ſelf with the ſame force, and preſs every way. Therefore if the air near the earth be included in any veſſel, without altering its denſity, the preſſure of the included air will be equal to the weight of the whole atmoſphere. Thus we find mercury ſuſtained to the ſame height by the elaſtic force of air included in a glaſs veſſel no way communicating with the external air, as by the weight of the whole atmoſphere.' *Id. Ibid.*

'The effects of the elaſticity of the air are like thoſe of its gravity; and included air acts by elaſticity, juſt as air not included, by its weight.' *Id. ibid.*

compreſſion, or expanſion; but ſtill, by the addition of a new weight, it will contract further; and by taking weight away, expand further †. And hence, as there is no end of its compreſſibility, there ſhould be none of its pores or vacuities.

*Cold condenſes air.* The colder air is, the leſs ſpace it poſſeſſes, and *vice verſâ*; hence cooling and compreſſing have the ſame effect thereon; nay, and cold and compreſſion keep pace with each other. The ſame holds of warming, and diminiſhing of weight; or heat and expanſion, which go hand in hand.

Thus, tho the air in high places is colder than nearer the ſurface of the earth; as all who have travelled the higheſt mountains agree; conſequently, the air there muſt contract it ſelf more in proportion: yet muſt the air of the ſame places, conſidered as it is preſſed with a leſs load of incumbent air, expand it ſelf more *. And hence the barometrical experiments made on the tops of the higheſt mountains, are frequently very wavering and precarious.

*The rarefactive force of heat, proportional to the degree of condenſation.* Monſieur *Amontons* firſt diſcovered, that air, the more it is condenſed, the more it will expand with the ſame degree of heat; conſequently, the more it is condenſed, the greater is its elaſticity. Now the condenſation is in the reciprocal ratio of the weights wherewith it is preſſed; and hence, if the air be preſſed in one place, or at one time, an hundred times as much as at another, its expanſive force, in the latter caſe, will be an hundred times that of the former ||.

*Effects,*

† Dr. *Halley* aſſerts, in *the Philoſophical Tranſactions*, that, from the experiments made at *London*, and by the academy *del Cimènto* at *Florence*, it may be ſafely concluded, that no force is able to reduce air into eight hundred times leſs ſpace than it naturally poſſeſſes on the ſurface of the earth. In anſwer to which, *M. Amontons* maintains that there is no fixing any bounds to its condenſation at all; that greater weights will ſtill bring it into leſs compaſs; that it is only elaſtic in virtue of the fiery particles it contains; and that it is impoſſible abſolutely to drive out all the fire, and conſequently to make a perfect condenſation. *Mem. de l' Acad. Ann.* 1703.

* The rule of this dilatation is, that the ſpaces poſſeſſed by the air are always inverſly as the forces whereby it is compreſſed.

|| On this principle, *M. Amontons* has a diſcourſe to prove that the weight and ſpring of the air, with a moderate degree of warmth, may enable it to produce earthquakes, *&c.* According to the experiments of *M. de la Hire*, and *M. Amontons*, a column of air on the ſurface of the earth, 36 fathoms high, is equal in weight to 3 lines of mercury; and it is found, that equal weights of air poſſeſs ſpaces reciprocally proportional to the weights wherewith they are preſſed: The weight of air, therefore, which would fill the whole ſpace poſſeſſed by the terreſtrial globe, would be equal to a cylinder of mercury whoſe baſe is equal to the ſurface of the earth, and its height contains as many times 3 lines as the atmoſpherical ſpace contains orbs equal in weight to that of the 36 fathoms whereof the experiment was made.

Hence, taking the denſeſt of all bodies, *e. g.* Gold, whoſe gravity is about 14630 times greater than that of air in our orb, it is eaſy to compute, that this air would be reduced to the ſame denſity as gold by the preſſure of a column of mercury 14630 times 28 inches high, *i. e.* 409640 inches; ſince the bulks of air, in that caſe, would be in the reciprocal ratio of the weights wherewith they are preſſed: this 409640 inches, therefore, expreſſes the height at which the barometer muſt ſtand, where air would be as heavy as gold; and the number $2\frac{51632}{4096640}$ lines, the thickneſs to which our column of 36 fathoms of air would

## *Effects, or Powers, of* Air.

*Air binds up, and keeps together the part of bodies.*

THE first effect of air is, that by being heavy and fluid, it invests the whole earth, and presses all the bodies thereon, with a great force; equal to what they would sustain from a pressure of 29 inches depth of mercury, or 32 feet of water †. By this means it binds up, and restrains terrestrial bodies; and thus prevents *e. g.* the arterial vessels of plants, and animals, from being too much distended by their circulating juices ||; and thus also hinders the juices from escaping out of the same. This is felt very sensibly in such as climb the tallest mountains; who find, that the higher they go, the more languid, relaxed and diffused they grow; till at length, they fall into a spitting of blood, and other hæmorrhages; by reason the air does not bind up the vessels of the lungs enough. The same we observe, in animals inclosed in the receiver of an air-pump; for, upon exhausting the air, they swell, vomit, drivel, dung, urine, sweat, *&c.*

would be reduced in the same place. Now, we know, that 409640 inches, or 43528 fathoms, is only the seventyfourth part of the semi-diameter of the earth: and when you are past that, whatever matters there be, they must be lighter than air. 'Tis not improbable, therefore, that the remaining sphere of 6451538 fathoms diameter, may be full of dense air, heavier by many degrees than the heaviest bodies among us.

Hence, again, as it is proved that the more air is compressed, the more does the same degree of fire increase the force of its spring, and render it capable of so much the greater effect; and that, for instance, the heat of boiling water increases this spring of our air beyond what it ordinarily is, by a quantity equal to one third of the weight wherewith it is pressed: we may infer, that a degree of heat which in our orb can only produce a moderate effect, may have a very violent one in such lower orb; and that as there may be many degrees of heat in nature beyond that of boiling-water, 'tis probable there may be some whose violence, thus assisted by the weight of the air, may be sufficient to tear asunder the solid globe. *Mem. de l' Acad. Ann.* 1703.

† 'The atmosphere, in its free state, may 'be considered as if it had once been wa-'ter, covering the earth, to the height of '31 feet; but afterwards exceedingly rarified, 'expanded and converted into what we call 'air; which, tho in fact it possesses a larger 'space, has not a greater weight than wa-'ter of the height of 31 feet. Now 'tis easy 'to compute what quantity of water would 'every way surround the earth, to that height; 'which gives the whole weight of the air: for, 'since a cubic foot of water weighs 72 pounds, 'a prism thereof (to use that for the sector 'of a sphere) whose base is a foot square, 'and height 31 feet, will weigh 2232 pounds; 'and since the surface of the earth con-'tains 3711.420000.000000 square feet, 'the product of these two sums, which is '8.283889.440000.000000 pounds, gives 'the quantity of water, and consequently the 'quantity of air required.' *Paschal. Traite de l' Equilibre des Liqueurs.*

'Hence, when a column of quick-silver, 'thirty inches high, is sustained in the baro-'meter; as it frequently happens; a column 'of air that presses upon an inch square near 'the surface of the earth, must weigh above 'fifteen Averdupoise pounds.' *Id. ibid.*

|| Thus the difference of the air in point of gravity may come to have a very considerable influence on the healths of men: 'When the 'air, says Mr. *Boyle*, grows of a sudden 'much lighter than usual, the spirituous and 'aerial particles plentifully lodged in the blood, 'will naturally swell that liquor; and so dis-'tend the greater vessels, and alter the man-'ner of the circulation thro' the capillary 'veins and arteries: whence several changes 'may happen in the body.' *Hist. of Air.*

*Mixes bodies.* 2°, It mixes different bodies together; for in being fluid, heavy and elaſtic, it can never be at reſt; ſo that wherever it is preſent, it is always acting on the ſurfaces of contiguous bodies: and hence ariſe various mixtures of fluid matters. This is apparent enough in many liquids, as oils and ſalts which mix readily in air; but taking that away, remain quietly in their ſtate of ſeperation.

*Makes bodies act on one another.* 3°, It determines the action of one body to another. Bodies, we obſerve, would not have any effect on each other in vacuo; and 'tis by means of gravity that the actions of bodies are ordinarily communicated. Without ſuch gravity, all bodies would be indifferent as to any motion; ſo that 'tis by means of this quality that the air ſo much as touches us.

*Fire on fuel.* One great circumſtance on which the action of bodies depends, is the preſſion of one body againſt another; which preſſion is frequently the effect of ſome other heavy body, and more particularly the air: thus the fire which burns wood, immediately goes out, and its flame diſſipates, upon taking the air away; by reaſon there is wanting ſomething to preſs the particles of fire againſt thoſe of the fuel, and prevent the too ſpeedy diffuſion of the flame *. And the ſame is obſerved in *aqua regia* and gold:

* We are extremely apt to be too precipitate in our concluſions: after having learnt a few of the properties of a body, we think we have got all, and impoſe it on our ſelves to account for all the phænomena and effects thereof, how various ſoever, from what we do know. Hence innumerable crude, conſtrained ſolutions. No body appears to have been more on his guard, in this reſpect, than Mr. *Boyle*: he ſaw abundance of effects from air, which did not appear to have any dependance on the known mechanical properties thereof; and on this view compoſed that excellent piece of *Suſpicions about ſome hidden qualities of the Air*. 'The difficulty, *ſays he*, we find in 'keeping flame and fire alive, tho but for a 'little time, without air, renders it ſuſpici-'ous, that there may be diſperſed thro' the 'atmoſphere, ſome odd ſubſtance, either 'of a ſolar, aſtral, or ſubterraneous nature; 'on account whereof, the air is ſo neceſſary 'to the ſubſiſtence of flame. And this ne-'ceſſity I have found to be more conſide-'rable, and leſs dependent upon the manifeſt 'attributes of the air, than is uſually ob-'ſerved; for by trials purpoſely made, it has 'appeared that a ſmall flame of a lamp, tho 'fed perhaps with a ſubtile thin oil, would, 'in a large receiver, expire for want of air, 'in a far leſs time than one would believe. 'And it will not much leſſen the difficulty to 'alledge, that either the groſs fuligenous ſmoke 'in a large veſſel, ſtifled the flame; or that 'the preſſure of the air is requiſite to impel 'up the aliment into the wiecks; for to ob-'viate theſe objections, it may be obſerved, 'that the experiment holds of ſpirit of wine, 'which, in the open air, will burn quite a-'way, without any ſenſible ſmoke; and this 'without any wieck at all.

Again,—'It ſeems ſurprizing what ſhould 'be in the air, which enabling it to keep 'flame alive, does yet, by being conſumed or 'removed, ſo ſuddenly render the air unfit to 'preſerve flame. It ſhould ſeem, by the ſud-'den waſting or ſpoiling of this fine ſubſtance, 'whatever it be, that the bulk of it is but 'very ſmall in proportion to the air it im-'pregnates with its virtue; for after the ex-'tinction of the flame, the air in the re-'ceiver was not viſibly altered, and, for 'ought I could perceive by ſeveral ways of 'judging, the air retained either all, or the 'greateſt part of its elaſticity, which I take 'to be its moſt genuine and diſtinguiſhing 'property. This undeſtroyed ſpringyneſs of 'the air, with the neceſſity of freſh air to the 'life of hot animals, ſuggeſts a great ſuſpi-'cion of ſome vital ſubſtance, if I may ſo 'call it, diffuſed thro' the air, whether it be 'a volatile nitre, or rather ſome anonymous 'ſubſtance, ſidereal or ſubterraneal; tho not 'improbably

'improbably of kin to that which ſeems ſo 'neceſſary to the maintenance of other flames.' *Ibid.*

Inſtances of ſtrange anonymous effects of the air, ſufficient to countenance ſuch ſuſpicions, we have enough. To what occur in the courſe of this and the following chapter, we ſhall here add another, *viz.* the appearance or growth of ſome ſalts, in certain bodies, which afford them not at all; or nothing near in ſuch plenty, or ſo ſoon, unleſs they be expoſed to the air.

Mr. *Boyle* cauſing a ſolid marcaſite, hard as ſtone, to be broken, that the internal and more ſhining parts might be expoſed to the air; he found, that tho this was done in a room where a good fire was uſually kept, ſo that the marcaſite was not only ſheltered from the rain, but kept in a dry air; yet after a while, there appeared on this glittering part, an effloreſcence of a vitriolic nature. Afterwards meeting with a ponderous, dark-coloured mineral, which at the very firſt breaking diſcovered to the eye no appearance of any ſalt, nor ſo much as any ſhining marcaſitical particles; he found, that a large quantity of theſe hard and heavy bodies being kept expoſed to the air, even in a room that preſerved them from rain, tho probably they had lain many ages intire under ground, in the hill where they were found; yet, in a few months, by the operation of the air upon them, were in a great part crumbled to a powder, exceeding rich in copperas. Nay, having laid up ſome of theſe ſtones in a room, where he conſtantly kept a fire, and in the drawer of a cabinet, which he did not often take out to give them freſh air, moſt of them were covered with a large effloreſcence; which, by its conſpicuous colour, between blue and green, by its taſte and fitneſs to make in a trice an inky mixture with an infuſion of galls, ſufficiently manifeſted it ſelf to be vitriol.

That the earth, or ore of alum, robbed of its ſalt, will in tract of time recover it, by being expoſed to the air, we are aſſured by the experienced *Agricola*. And Mr. *Boyle* obſerves, that ſome kind of lime in old walls, and moiſt places, has, in time, gained a large effloreſcence, very much of a nitrous nature; as he was convinced by having obtained ſalt-petre from it, upon barely diſſolving it in common water, and evaporating the filtred ſolution.

It may ſeem doubtful, whether the ſalts appearing in the fore-mentioned caſes are really produced by the operation of the air workirg as an agent, or alſo concurring as an ingredient; or whether theſe ſaline ſubſtances proceed not from ſome internal thing, analogus to a ſeminal principle, cauſing in them a kind of maturation of ſome parts; which being once ripened, and perhaps aſſiſted by the moiſture of the air, diſcloſe themſelves in the ſaline concretions; as in the feculent or tartarous part of wines, there will, in tract of time, be generated or produced numerous corpuſcles of a ſaline nature, that give the acid taſte we find in tartar, eſpecially in that of rheniſh wine.

It may alſo be ſuſpected, that the ſalts found in marcaſites, nitrous and aluminous earths, *&c.* are made by the ſaline particles of the like nature, that, among multitudes of other kinds, ſwim in the air, and are attracted by ſimilar particles yet remaining in the terreſtrial bodies, which are, as it were, the wombs of ſuch minerals; as a ſpirit of nitre will with fixed nitre, and ſome other alkalies, compoſe ſalt-petre: or elſe, that ſuch aerial ſalts, aſſiſted by the moiſture of the air, ſoften, open, and almoſt corrode, or diſſolve the more terreſtrial ſubſtances of theſe wombs, and thereby ſollicit and extricate the latent ſaline particles; and by their union with them, compoſe thoſe reſulting bodies that reſemble vitriol, alum, *&c.*

But tho theſe conſiderations ſhould be thought ſufficient to reſcue the production of ſalts from the effect of any hidden properties of the air, we have others which abundantly evince the exiſtence of ſuch properties: as, the air's acceſs rendering antimonial medicines not only emetic, but alſo diſpoſed to produce heart-burnings, faintings, *&c.* none of which, when kept from the air, they do at all tend to promote. Its affording ſtrange prognoſticks of plagues; as that of the perſon mentioned by Mr. *Boyle*, who for three ſucceſſive plague-ſeaſons had an odd tumour formed in his groin, about three months ere the plague began; by which he conſtantly foretold its approach: with infinite others to be met withal in naturaliſts, chemiſts, *&c.* as *Zwelfer*, *Boyle*, *Cardan*, *Scaliger*, *Diemerbroeck*, &c.

To account for the origin of ſuch properties of the air, Mr. *Boyle* obſerves, that as we cannot pronounce ſo much as negatively whether the libration of the moon, and the motion of the ſun, and perhaps of ſome of the other planets, about their own centres, and conſequently their turning ſeveral parts of their bodies,

gold: that menſtruum is found to act on this metal, partly by its gravity, and partly by the preſence of the air; for, upon removing the air, it ceaſes any longer to diſſolve the gold.

*Illuſtrated by Papin's digeſtor.* The vaſt effect of air, in determining bodies to one another, I have made trial of with great hazard of my life: for, putting a little ſpirit of wine, along with ſome of the more tenacious bodies, as gum ſandarach, *&c.* in *Papin*'s digeſtor, to diſſolve; and applying a fire underneath; the air not being able to eſcape, expanded it ſelf with immenſe force, and thus violently thruſt the ſeveral matters againſt each other: ſo that the whole was, in a very ſhort time, perfectly diſſolved. But ſuch was the expanſive force of the impriſoned air, that a metalline cylinder, two inches thick, was thereby burſt in my hand.

*Agitates the parts of bodies.* 4°, Air being thus elaſtic, and inſinuating it ſelf into the pores of bodies, with ſo powerful a property of expanding, and this ſo eaſy to be excited; it muſt of neceſſity put the particles of all bodies it is mixed withal, into perpetual oſcillations; unleſs theſe three conditions concur: 1°, That the gravity, or weight, wherewith it is preſſed, remain the ſame. 2°, That the elaſtic force remains the ſame. 3°, That the contained fire continue the ſame, without augmentation or diminution. But, as ſuch weight, elaſticity, and rarefaction, are continually varying; it follows, that there muſt be an almoſt inceſſant vibration, or dilatation and contraction in all bodies.

*Exemplified in ice, glaſs, marble, &c.* Monſieur *Mariotte* obſerves, that if there be bubbles of air contained in a piece of ice; that air ſeeking it ſelf a paſſage, will break the ice: and thus it is, that glaſſes, and other veſſels, are frequently burſt in the

bodies to us, may not have an operation upon our atmoſphere; ſo, for ought we know, there may be in thoſe vaſt internal parts of the earth, whoſe thin cruſt has been here and there dug into, conſiderable maſſes of matter that have periodical revolutions, accenſions, eſtuations, fermentations, or in ſhort, ſome other notable commotions; the effluvia whereof may produce effects yet unobſerved on the atmoſphere, and on ſome particular bodies expoſed to it: tho theſe periods may, perhaps, be altogether irregular, or have ſome kind of regularity different from what one would expect: thus the ſea has thoſe grand intumeſcencies we call ſpring-tides, not every day, nor at any conſtant day of the month or week, but about the full and new moon; and theſe ſpring-tides are moſt notably heightened, not every month, but twice a year; at or about the vernal and autumnal equinoxes: which obſervations are not near ſo antient, and ſo well known, as the daily ebbing and flowing of the ſea. The Eteſians of the antients we do not now inſiſt on, nor the obſervations of the elder inhabitants of the *Caribbee-Iſlands*; who, when the *Europeans* firſt reſorted thither, had hurricanes but once in ſeven years; afterwards they were moleſted with them once in three years; of late they have been troubled with them almoſt every year: And a phyſician who had lived there ſince, aſſured us, he had ſcarce obſerved them to ſucceed one another in leſs compaſs than of two months. In which inſtances, and in ſeveral others, it may be noted, that in the changes which happen to great quantities of matter, nature ſeems to affect ſomething of the periodical, but not in a way that appears to us regular. We may add what *Varenius* relates of thoſe hot ſprings in *Germany* he calls *Thermæ piperinæ*, that they annually begin to flow at certain ſeaſons; the former about the third of *May*, and the latter near the middle of *September*; from which time they reſt till the following ſpring: To ſay nothing of numerous other periodical ſprings which flow, ſome of them ſo many hours, and ſome ſo many days, and then reſt as many, alternately. *See* Boyle, *as above cited.*

winter

winter time, when the liquors they contain are frozen. Air, indeed, may remain in certain places, without activity; till, by ſome accidental union with other particles, it acquires an activity: and hence it is, that entire columns of marble, ſometimes cleave in the winter ſeaſon, from ſome little bubble of included air's acquiring an increaſed elaſticity.

All ſolutive power, therefore, depends on air: for, as is already obſerved, *aqua fortis* cannot diſſolve iron, or copper, in the receiver of an air-pump; but, when the air is let in, the ſolution is ſoon performed. And hence it is, that on the tops of high mountains, as the pike of *Tenariffe*, the moſt ſavory bodies, as ſalts, ginger, pepper, ſpirit of wine, *&c.* ſcarce affect the tongue and palate with any ſenſible taſte at all; their particles not being preſſed on the tongue, ſo as to enter its pores; but inſtead thereof, diſſipated and blown away by its heat: the only thing that there retains its taſte, is *Canary*-wine, which may be partly owing to its penetrative ſpirit, but probably, more to its oilyneſs, which makes it adhere more ſtrongly, and not ſo eaſy to be diſſipated by the heat of the tongue. Hence alſo it is, that ſalts do not diſſolve ſo well in dry places; but beſt in cold places under ground, where the air being heavier, preſſes the parts more towards each other.

*Air neceſſary to ſolution.*

*Taſtes.*

*The running of ſalts.*

As the air is elaſtic, and as it expands or contracts differently, according to the different degrees of heat, and cold; and as theſe are variable, and rarely continue two minutes the ſame; it follows, that the air muſt be in continual motion: and thus it becomes the great cauſe why motion never ceaſes in the univerſe. This air, we find, produces a vibratory motion in ſeveral bodies, obſerved particularly in plants; the air-veſſels whereof do the office of lungs: for, the air contained in them, ſometimes contracting, and ſometimes expanding, according as the heat is increaſed, or diminiſhed, preſſes the veſſels, and eaſes them again by turns; and thus promotes a circulation of their juices, which could ſcarce be otherwiſe effected. Hence, we find, that no vegetation or germination, will proceed in vacuo; for, as to what is commonly ſaid of beans, *viz.* that they germinate there, it is a manifeſt miſtake: indeed, they ſwell a little, by the expanſion of the air contained within them; but they never bud. Perhaps no ſpace can be aſſigned within the confines of our earth, but has air in it: to try whether there were any in a very intenſe fire, I placed a tube in a furnace, till it was ready to fuſe; then, hermetically ſealing it, as ſuppoſing it abſolutely void of fire, I immerged it, thus ſealed, in mercury, and in this condition broke off the ſeal: upon this the mercury roſe, but not ſo high as in the barometer; which ſhews that there was ſtill air in the tube to prevent its aſcent. Air, therefore, is found in a fire where glaſs will melt.

*Air the great inſtrument of motion.*

*Found in all places about our earth.*

And not only all ſolutions, but all putrefactions and fermentations, do likewiſe depend on the air, conſidered as it is elaſtic, and in continual motion; theſe two operations, which we ſhall hereafter ſhew are the grand means of changing, and converting vegetable and animal bodies, depend wholly on the action of the air, whoſe continual oſcillations are

*Air the great inſtrument of putrefaction and fermentation.*

inducing perpetual changes both in ſolid and fluid bodies, pervious thereto *. That the effect is not immediately owing to the action of fire *†, is evident hence; that there is the ſame degree of heat in vacuo, as in the open air; and yet no putrefaction enſues in vacuo, either of animal or vegetable bodies.

If you knead flour with water, void of all air, and lay it in vacuo; it will never ferment †: nor will fleſh putrefy without air; tho it may reſolve into a kind of ſanies or filth ‖. The like holds of liquids; none of which will ferment, but ſuch as have air in them, and at the ſame time are in ſome meaſure viſcid, to retain it. So, if you ſhut up apples, flowers, *&c.* in an exhauſted receiver, and keep them there for ſix months, they ſhall be found ſtill freſh and unaltered **.

* 'Are not the moiſt particles, which float 'in the air, the cauſe of all corruption in 'bodies; ſince, according to *Acoſta*, every 'thing in *Peru* (and the ſame is obſerved in '*Egypt*) where it ſeldom rains, continues long 'uncorrupted? or is this reſiſtance of putre-'faction rather owing to the nitrous ſalt where-'with the air of thoſe countries abounds?' *Boyle*'s *Hiſt. of Air*.

Mr. *Boyle* gives us ſome ſingular inſtances of the effect of the air, hardly deducible from any of the known properties of this fluid. Dr. *Stubbs* aſſured him, 'That the ſilks brought 'from *Jamaica*, will, if there expoſed to the 'air, rot even whilſt they preſerve their co-'lour; but if kept therefrom, hold both their 'ſtrength and die.' *Ibid.*

The ſame author was informed by a learned gentleman, 'That the air at *Braſil* had a 'great influence upon the colours of clothes, 'and even upon black; ſo that the ſable taffety 'there worn by the higher rank, will, in a 'few days, become of an iron colour; tho, 'when kept cloſe in ſhops, it preſerves its 'proper hue. He alſo informed him, that at 'a place fifty leagues beyond *Parigua*, white 'people ſoon grew tawney; and as ſoon re-'cover their native colour by removing out of 'that quarter.' *Ibid.*

*† Sir *Iſaac Newton* looks for ſomething finer than common air to produce many of the effects aſcribed thereto: finding that heat is conveyed and propagated even in vacuo, he ſuppoſes a fine ætherial medium, or ſpirit, ſubtile enough to penetrate freely thro' the moſt ſolid of all bodies. On which medium, fire and light have their firſt immediate effect, which is hence communicated, by the vibrations of this medium, to the air, and thence to other bodies. *Opticks.*

† 'The air, Sir *Iſaac Newton* obſerves, a-'bounds with acid vapours, fit to promote 'fermentations; as appears by the ruſting of 'iron and copper in it, the kindling of fire 'by blowing, and the beating of the heart by 'means of reſpiration.

'The above-mentioned motions, he adds, 'are ſo great and violent as to ſhew that in 'fermentations the particles of bodies almoſt 'at reſt, are put into new motions by a very 'potent principle, which acts upon them only 'when they approach one another, and cauſes 'them to meet and claſh with great violence, 'and grow hot with the motion, and daſh 'one another into pieces, and vaniſh into 'air, vapour, and flame.' *Opticks.*

‖ The generation of animal ſubſtance being the effect of putrefaction, as will hereafter be made appear; it follows, that the preſence of the air is neceſſary for any piece of matter to commence animal. Thus the philoſopher ſo often quoted, obſerves, that by keeping putrefied bodies in glaſſes hermetically ſealed, and thereby ſecured from the contact of the external air, he had never been able to produce any inſect, or other living creature; tho he had ſometimes kept animal ſubſtances, and even blood ſo included, for many months, and one or two of them for a longer time; and tho theſe ſubſtances had a manifeſt change made in their conſiſtence whilſt they remained ſealed up. *Ubi ſupra.*

** Opening an exhauſted receiver, wherein a large quantity of verjuice with green, ſour grapes, had lain included for three years, there appeared no mouldineſs any where; only the ſurface of the uppermoſt ſkins were a little diſcoloured with ſomething, which by its taſte, and appearance thro' a microſcope, I ſuſpected to be a kind of tartar. *Id. ibid.*

The

The effect of the air, therefore, appears very great; ſince it can change the two kingdoms, and convert ſubjects of the one, into thoſe of the other: what elſe is it that renders metals ſo very durable, and incorruptible, but their ſimplicity, and their not being pervious to the air? Thus, in places where no air is, there, no alterations happen; accordingly, it has been often obſerved, that names wrote in the ſand, on the tops of the higheſt mountains, have remained there forty years together, without having been the leaſt altered, or effaced.

## Air, *conſidered as a Chaos, a great Diſſolvent.*

NOW, the *air*, conſidered as a chaos, wherein all kinds of bodies float, may produce an infinite number of effects, hitherto not attended to.

There are two manners of diſſolving: the firſt depends on the common properties of body; and therefore is mechanical. Thus, wood becomes divided and attenuated by means of the hardneſs, figure, coheſion, and motion of a ſharp body, applied thereto. The ſecond by ſome proper diſſolvent or menſtruum: thus gold is only ſoluble by mercury, fire, and *aqua regia*.

Now, we have already ſhewn that air is a ſolvent in the firſt capacity; as, by its weight, and elaſticity it preſſes bodies againſt each other, and produces an attrition: and as it contains fire; which has likewiſe been ſhewn to be a diſſolvent.

But air is likewiſe a chaos; and muſt therefore contain all kinds of menſtruums; and conſequently have wherewithal to diſſolve all kind of bodies; ſo that the air muſt likewiſe diſſolve in the ſecond capacity †. *Air an univerſal menſtruum.*

† Mr. *Boyle* aſſures us, 'That he has ſeveral times made a ſubſtance, conſiſting of a metalline body of a texture ſo cloſe as to lay for many hours undiſſolved in a corroſive menſtruum; yet this ſubſtance, that was fixed enough to endure melting by the fire without loſing its colour, would, when expoſed to the air, be diſſolved in a very ſhort time, and have its ſuperficial parts turned almoſt black.' *Ubi ſupra.*

Air, 'tis obſerved, may have a notable operation on vitriol, even after a ſtrong fire could work no farther thereon. The experienced *Zwelfer* informs us, that the colcothar of this mineral, made by a ſtrong diſtillation, is not corroſive; and that no ſalt can be obtained from it ſoon after diſtillation, by the affuſion of water: but, ſays he, if it be for ſome time expoſed to the air, it will yield a ſalt, which is ſometimes white, and ſometimes a beautiful purple colour; and ſometimes alſo a nitrous kind.

Mr. *Boyle* has even found the fumes of a ſharp liquor to work more ſuddenly and manifeſtly on a certain metal, when ſuſtained in the air, than did the menſtruum it ſelf, that emitted thoſe fumes on thoſe parts of the metal it covered. And a chemiſt, who had been in *Hungary* and other parts, purpoſely to viſit mines, aſſured me, that as to the ladders and other wooden-works, employed in one or more of the deep *Hungarian* mines, thoſe that were in the upper part of the grooves, near the external air, would, by the fretting exhalations, be rendered unſerviceable in a few months; whilſt ſuch ladders, pieces of timber, &c. as were employed in the lower parts of the mine, would hold good two or three times as long. *Id. ibid.*

*Metals turned rusty thereby.* This, accordingly, is matter of general obſervation; every body knows that iron and copper grow ruſty in air. In the iſland of *Barbadoes* the air is ſo moiſt, that their inſtruments, unleſs well defended with oil, are ſoon diſſolved. *Acoſta* affirms, that the air in *Peru* diſſolves lead, and withal increaſes its weight: and we our ſelves have ſeen pillars of iron ſo reduced by air, that one might crumble them to duſt with the finger *: *Except gold.* and ſtones † frequently undergo the ſame fate. Indeed gold may ſeem inacceſſible to air; it being found never to contract ruſt, tho expoſed ever ſo long to the open air. The reaſon is, that the only ſalt in nature, which diſſolves gold, is the common ſea-ſalt; which is not eaſily made volatile. So that air may be conceived as an univerſal || menſtruum, now applying it ſelf to this body, and then to that; and thus inducing diſſolution, corruption, and putrefaction, in all things.

*Air volatilizes fixed bodies.* Air, in effect, not only diſſolves but *volatilizes* abundance of bodies, which before were fixed: thus, if you calcine ſea-ſalt by a vehement fire, and then fuſe it; and when fuſed, expoſe it to the air in an open veſſel, you *Even ſea-ſalt.* will find it liquify: when liquified, let it dry again; and when dry, fuſe it: and thus, by repeating the experiment, you will have all the ſalt vaniſh into air; leaving nothing behind but a little earth, and inſipid water.

*Air fixes volatile bodies.* For the ſame reaſon, air fixes divers bodies which before were volatile: thus, nitre, or *aqua fortis*, evaporate by fire, but if there be any

* 'Copper that has been long expoſed to 'the air, contracts a ruſt by the ſaline particles of that fluid, gradually faſtning themſelves in ſuch numbers to the ſurface of the 'metal as to corrode it, and produce a ſubſtance of the colour of verdigreaſe; which 'is a factitious body, made of the ſame metal, corroded by the ſharp corpuſcles of vinegar, or of the husks of grapes.' *Boyle Hid. Qual.*

'Tho *Morocco* be an inland town, ſeated 'in a very hot climate, where the ſoil is 'uſually dry; yet I am informed, that the 'nocturnal air proves exceeding damp and 'piercing, ſo as preſently to produce ruſt upon 'ſuch iron inſtruments as lie naked therein.' *Id. Hiſt. of Air.*

'In the moſt Southern parts of the *Engliſh* 'colonies, the great guns are ſo ſubject to 'ruſt, that after lying a few years in the 'open air, large cakes of *crocus martis* may, 'with a hammer, be eaſily beat off them; 'whilſt others that lay ſunk in the ſalt-water, 'during the ſame time, are by no means ſo 'much affected. Hence, as dew is only 'ſteams of the terreſtrial globe, the phænomena that manifeſt its power to work on 'ſolid bodies, may help to ſhew how much 'the air abounds with ſaline and ſubtile parts.' *Id. ibid.*

† An experienced maſon told me, that *Saliſbury* cathedral is built of *Purbeck* ſtone, which gradually becomes ſofter, and moulders away in the air; that the ſame is obſerved from *Blackington* ſtone, tho kept from the wet: but what comes from *Painſwick*, within four miles of *Gloceſter*, tho ſoft and pliable at the firſt, will, by lying in the air, acquire an hard, yellowiſh, glaſſy cruſt, like marble; which grows the more durable for being often waſhed. *Boyle, Hid. Qual.*

|| 'In bodies on which the aerial menſtruum 'can operate, its immenſe quantity is of 'ſome advantage: for whereas even the 'ſtrongeſt menſtrua, if they bear no great 'proportion, in bulk, to the bodies they are 'to work on, are eaſily glutted, and being 'unable to take up any more, leave the reſt 'of the body undiſſolved; this bears ſo vaſt 'a proportion to the bodies expoſed to it, that 'when one portion of it has impregnated it 'ſelf as much as 'tis able, there may ſtill 'come freſh to operate farther on the remaining part of the body.' *Id. ibid.*

putrefied urine near the place, the volatile ſpirit will be fixed, and fall down in form of *aqua ſecunda* †.

Add, that air brings a great many quieſcent bodies into action, *i. e.* ſtirs up, and excites their latent powers: thus, if an acid vapour be diffuſed thro' the air; all things whereof that is a menſtruum, will be diſſolved thereby. Thus gold is diſſolved by the vapour of ſpirit of ſea-ſalt, and ſilver by that of nitre; and each contracts a ruſt: ſo that it was no groundleſs obſervation of the chemiſts, that there are active principles in the air.

*Brings the latent powers of bodies into action.*

From the whole we gather, that the objects of chemiſtry, in the ſame operation, applied in the ſame manner, and to the ſame fire, will not have the ſame effects, at different times, or in different places; by reaſon of the diverſity of matters in the air.

Air, conſidered, both as inveſted with the forementioned properties, *viz.* gravity, elaſticity, *&c.* and as a chaos, may have infinitely various effects, which none but a chemiſt would know how to account for: ſome operations require an open air, without which they can never take; and in others, on the contrary, the air is to be totally excluded. If you take camphire, put it in a glaſs veſſel, and ſet fire underneath it; the whole will run into ſalts, without any diminution of weight; whereas, if during the proceſs, you take off the cover, and apply a candle to it, it will take fire, and the whole fly away in fume. So, to make ſulphur inflammable, it requires the air; for in a cloſe cucurbit it may be ſublimed a thouſand times without kindling: put ſulphur under a glaſs bell, and apply fire; and it will riſe into ſpirit of ſulphur *per campanam*; and provided the veſſels were cloſe, will be incapable of catching fire, as much as gun-powder in the ſame circumſtances: but if there be but the leaſt chink, it immediately kindles. So an ounce of charcoal, incloſed in a crucible well covered and luted, to prevent any air's inſinuating; may be kept in the intenſeſt heat of a melting furnace fourteen days without any loſs; and yet the thouſandth part of the fire, in open air, readily turns it into aſhes. *Helmont* relates, that if you take charcoal and put it in a cloſe veſſel, out of which the air is excluded, and here urge it for fourteen days in a glaſs furnace; the coal will ſtill remain black: but the minute you let in air, it falls into white aſhes. The ſame holds of the parts of all animals and vegetables, which can only be calcined in open air: in cloſe veſſels, they will never be other than black coals.

*Diverſities in the air produce others in chemical operations.*

† Mr. *Boyle* mentions a certain ſoft but conſiſtent chemical body, which in the free air continually emitted a thick ſmoke; but which, in an exhauſted receiver, was not found to emit any: nay, by lying a-while in vacuo, it grew ſo far fixed, that it afterwards remained a good while in air, ere it would ſmoke again. And what was farther yet, when a vial, containing ſome of it, was put unſtopped in the receiver of the air pump, cloſe luted on; tho no exhauſtion were made, yet the white fumes immediately ceaſed to aſcend; as if the ſmoke participated of the nature of flame, and preſently glutted the air, or otherwiſe made it unfit, without any diminiſhing of its gravity, to raiſe the body. *Hid. Qual. of Air.*

*Diversities in the exhalations produce others in the operations.*

The changes, therefore, produced by chemiſtry are various, according as they are made in the open or incloſed air; rarefied, or denſe; humid, or dry; light, or heavy, *&c.*

The ſame are likewiſe various, as the exhalations are ſo. We ſhall ſhew elſewhere that ſalts attract, and that air repels, water. *Helmont* mentions it as a mighty arcanum in chemiſtry, to render fixed ſalt of tartar volatile; but the thing is effected by air alone: for if you expoſe ſome of this ſalt to the air, in a place replete with acid vapours, the ſalt will draw the acid ſpirit to it ſelf; and when ſaturated therewith, become volatile. But then it is no longer a mere alcaline ſalt, but a compound one. Hence a due regard to the ſtate and diſpoſition of the atmoſphere, of the place, *e. g.* the air of the laboratory, is indiſpenſibly required in any operation; without which, there is no anſwering for the event's being the ſame at one time as another. If *e. g.* there were 100 men in a place, the air, there, would be full of the matter of inſenſible perſpiration; and a good blood-hound would readily diſtinguiſh that emitted by his maſter from all the reſt, by the mere ſmell: Hence it follows, that the air muſt be very different where crouds of people are, as in cities, great aſſemblies, *&c.* from what it is in rural and ſolitary places. Thus much for air.

Of

# *Of* WATER.

WATER is a thing of a very extraordinary and wonderful nature, hitherto little known or underſtood. When conſidered in itſelf, it appears to be of the nature of a pure cryſtal: for a ſmall degree of cold renders it, as it were, ſtony; and a great one turns it perfectly hard; ſo as even armour might be framed thereof. But fire puts it in motion; and by means hereof it becomes a fluid. *Water not fluid of its own nature.*

Water, if it could be had alone and pure, would be as ſimple as fire; but there is no art or expedient yet found out for making it ſuch: for rain-water, which ſeems to be the pureſt of all the waters we know of, is replete with exhalations of all kinds, which it imbibes from the air; ſo that tho filtred and diſtilled a thouſand times, there ſtill remain fæces behind; and if it be let ſtand a little while, it corrupts and ſtinks. The rain-water gathered from the roofs of houſes is a lixivium of tyles, ſlate, or the like, impregnated with the dungs and fæces of animals, birds, *&c.* depoſited thereon, and the exhalations of numerous other things. All the rain-water gathered in cities muſt at laſt be ſaturated with the ſmoke of a thouſand chimneys, and the various effluvia of numbers of perſons, *&c.* Add, that there is fire contained in all water; as is evident from its fluidity, which is owing to fire alone. *None of our water pure.* *Rain-water a ſtrange compound.* *No water without fire.*

There is always ſomething heterogeneous, therefore, remaining in water, as well as air; and as what is in the air neceſſarily mixes itſelf with water, it appears impoſſible to have ſuch a thing as pure water: if you percolate it thro' ſand, or ſqueeze it thro' pumice, or paſs it thro' any other body of like kind, you will always have ſalt remaining. Nor can diſtillation render it pure; ſince it leaves the air therein, which abounds in corpuſcles of all ſorts. Accordingly we find that water, tho diſtilled again and again, never fails to leave fæces behind; which Mr. *Boyle* aſſures us has been proved, even to the hundredth diſtillation. *No operation to make water pure.*

Some years ago, I placed a large chemical veſſel on the turret of our academy, in a clear night, when not a breath of wind ſeemed ſtirring; in order to gather the water, as it fell, in form of dew, or hoar-froſt: hoping that by the great height of the place, and the precautions I had taken to prevent the admixture of any foreign matter, I ſhould have water in all its purity. But tho the water thus procured, was the pureſt I had ſeen; yet, by a gentle diſtillation continued for the ſpace of a month, with a heat no greater than that of the human body, it left fæces full of various ſorts of heterogeneous particles.

Hence I am convinced no body ever ſaw a drop of pure water. The utmoſt of its purity known, only amounts to its being clear of this or

that ſort of matter. It can never, for inſtance, be quite deprived of ſalt; ſince air will always accompany it, and air has always ſalt.

## Water *an univerſal Inſtrument.*

*Water concern'd in all operations.* WATER is an univerſal inſtrument, concerned in almoſt all operations: for there is no air without water, as we have already ſhewn; nay, and what is more extraordinary, there is no fire without *Contained in all bidies.* water. A ſingle grain of the moſt fiery ſalt, which in a moment's time will penetrate thro' a man's hand, readily imbibes half its weight of water, and melts even in the drieſt air imaginable. Thus ſalt of tartar, placed in the drieſt air, and near the hotteſt fire, will attract or imbibe water; and by that means increaſes conſiderably its weight in a ſmall time. So in the drieſt ſummer's-day, bring up a veſſel, *e. g.* of *In all ploces.* pewter, with ice in it, from ſome cold ſubterraneous place, into the hotteſt room; and it ſhall no ſooner be entred, than its whole ſurface will be covered with little drops of water, gathered from the contiguous air, and condenſed by the coldneſs of the ice. Thus the windows of all hot places are continually found wet on the outſides; ſo that water is diffuſed every where. Which is further confirmed by the following experiment:

I took a quantity of rightly prepared oil of vitriol, and expoſed it a long time to a violent fire to ſeparate all the water, as much as poſſible, from the ſame; afterwards, by only ſtanding a little while in the air, it contracted freſh water apace: ſo that it ſoon afforded me a *Hartſhorn as hard as metal, ſtones, &c.* conſiderable quantity more. I have harts-horn which has been kept for forty years, and is as hard and dry as any metal; ſo that if ſtruck againſt a flint it will yield ſparks of fire. And yet this very hartshorn, being put in a glaſs veſſel and diſtilled, afforded me $\frac{1}{8}$th of its *Plentifully found in dead dry bones.* quantity of water. We have known bones dead and dried twenty five years, and thus become almoſt as hard as iron; which yet, by diſtillation, afforded half their weight of water: and the hardeſt ſtones, ground and diſtilled, do always diſcover a portion thereof.

## *Opinions of Philoſophers concerning* Water.

*Water held the ſeminal matter of all things.* *THALES*, the *Mileſian*, held, that all things were made of water; which opinion he had probably borrowed from the writings of *Moſes* *, where he ſpeaks of the Spirit of God's moving on the face of the *waters*.

After

* With regard to this, Mr. *Boyle* obſerves, 'That he ſees no neceſſity to conceive, that 'the water mentioned by *Moſes*, on which 'the Spirit is ſaid to have brooded, as the 'univerſal matter; was our elementary 'water; ſince, tho we ſhould ſuppoſe it to 'have

After him, *Basil Valentine*, *Paracelsus*, *Van Helmont*, *Centivoglio*, and others, have maintained, on his principles, that water is the elemental matter, or stamen of all things; and that it suffices for the production of all things: which *Helmont* endeavours to prove from the following experiment.

He burnt a quantity of earth in a potter's vessel, till such time as all the oil it contained was quite consumed; then mixing it up with water, he drew out all the salt. The earth thus prepared, he put in an earthen pot, such as is used by gardiners; and took care that nothing but rain-water could enter into the same. And yet a willow being planted in this earth, grew up to a considerable height; whence he concluded, that water was the only nutriment of the vegetable kind, as vegetables are of the animal *.

Helmont's *experiment to prove it.*

'have been an agitated congeries, consisting 'of a great variety of seminal principles, and 'of other corpuscles fit to be subdued and 'fashioned by them, it might yet be a body 'fluid, like water, in case the corpuscles it 'was made up of, were, by their Creator, 'made small enough, and put into such an 'actual motion as might make them all roll, 'and glide over one another. And as we 'now say, the sea consists of water, not-'withstanding the saline, terrestrial, and other 'bodies mixed with it; such a liquor as the 'former might well be called water; because 'that was the nearest of the known bo-'dies whereto it was like. But that bodies 'may be fluid enough to appear a liquor, and 'yet contain corpuscles of a very different na-'ture, appears from exposing a quantity of 'vitriol in a strong vessel to a competent 'fire; for tho it contains aqueous, earthy, 'saline, sulphureous and metalline parts, yet 'the whole mass will at first be fluid, and 'boil like water.' *Scept. Chem.*

Dr. *Lister*'s sentiment is not very remote from this: he imagines sea-water to have been the only element created at the beginning, before any animal or vegetable; or even before the sun himself. Fresh water he supposes to have arose accidentally, after the creation of these; and to owe its origin to the vapours of plants, the breath of animals, and the exhalations raised from the sun. *De Font. Med. Ang.*

Dr. *Halley* is of another opinion: he takes it for granted, that the saltness of the sea arises from the saline matters dissolved and imbibed by the rivers in their progress, and discharged with their waters into the ocean; and consequently, that the degree of saltness is continually and gradually increasing. On this hypothesis he even proposes a method for determining the age of the world: for two experiments of the degree of saltness, made at a large interval of time, will, by the rule of proportion, give the time wherein it has been acquiring its present degree. *Philos. Transact.* N° 344.

* Tho *Helmont* produces no instance of any mineral body, and scarce of any animal, generated of water; yet a *French* chemist, *M. de Rochas*, affords us an experiment, which if it succeeded as he delivers it, is very remarkable. 'Having, *says he*, found sur-'prizing things from the natural operation of 'water, I was willing to know what might 'be done with it by art: I therefore took 'pure water, and by a heat artificial, conti-'nual, and proportionate, I prepared and 'disposed it by the coagulation, congelation, 'and fixation, till it was turned into earth; 'which produced animals, vegetables, and mi-'nerals. The animals moved of themselves, 'eat, *&c.* and by the anatomy I made of 'them, I found them composed of much sul-'phur, little mercury, and less salt. The mi-'nerals began to grow and increase, by con-'verting into their own nature one part of 'the earth thereto disposed; they were solid 'and heavy.'

For the generation of living creatures, both vegetable and sensitive, it need not seem incredible; since we find that our common water, which is often impregnated with variety of seminal principles, long kept in a quiet place, will putrefy; and then too, perhaps, produce moss and little worms, or other insects, according to the nature of the seeds that were lurking in it. *Boyle's Scept. Chemist.*

The ſame thing Mr. *Boyle* likewiſe argued from a ſimilar experiment. But Dr. *Woodward* ſhews that they were both miſtaken: he proves, that water contains in it divers extraneous corpuſcles, and that ſome of theſe are the proper matter of nutrition; water being found to afford ſo much the leſs nouriſhment, the more it is purified: thus mint planted in water purified by diſtillation, will not grow ſo faſt as if put in water not diſtilled; and if the water be diſtilled three or four times over, the plant will ſcarce grow at all, or receive any nouriſhment from it. So that water, as ſuch, is not the proper nutriment of vegetables, but only the vehicle thereof, which contains the nutritious particles, and carries them along with it, thro' all parts of the plant. So that a water-plant, *e. g.* a naſturtium, being put in a glaſs veſſel, full of water, will be found to contain the more ſalt and oil, the muddier the water is; in effect, water nouriſhes the leſs, the more it is purged of its ſaponaceous ſalts: in its pure ſtate, it may ſuffice to extend, or ſwell the parts; but affords no new vegetable matter.

*Diſproved by Dr.* Woodward.

*Pure water affords no nutriment.*

*All bodies held convertible into water. Particularly all ſpirits.*

*Helmont* likewiſe imagined, that all bodies might be converted into pure elementary water *. From mixed bodies, 'tis certain, we can draw *water*, *oil*, *ſpirit*, *ſalt* and *earth*. Now *ſpirits* cannot be better repreſented than by alcohol of wine; which, *Helmont* affirms, may be ſo united with water, as to become water it ſelf †.

*Salts.*

As to *ſalts*; ſalt of tartar well calcined, being laid to liquify in air, will depoſit an earth; and if it be then committed to diſtillation, will yield a conſiderable quantity of inſipid water; inſomuch, that if it be urged with a vehement fire, the ſalt will almoſt all vaniſh, and nothing ſaline remain either in the water or the earth. Whence *Helmont* concluded, that all ſalts might be converted into water. As to the converſion of acid ſalts into water; ſea-ſalt, recover'd from the acid ſpirit of ſea-ſalt and oil of tartar, melts into water, as much as into oil of tartar. Laſtly,

*Acid ſalts.*

* *Helmont* affirms, that his alkaheſt adequately reſolves plants, animals, and minerals, into one liquor, or more, according to their ſeveral internal differences of parts; and that the alkaheſt, being abſtracted from theſe liquors, in the ſame weight, and with the ſame virtues as when it diſſolved them, the liquors may, by frequent cohobations from chalk, or ſome other proper matter, be totally deprived of their ſeminal endowments, and return at laſt to their firſt matter, inſipid water.

† Tho ſpirit of wine exquiſitely rectified, ſeems of all liquors the moſt free from water, yet even this is by *Helmont* affirmed to be materially water, under a ſulphureous diſguiſe; for, according to him, in making *Paracelſus*'s *balſamus ſamech* (which is nothing but *ſal tartari* dulcified, by diſtilling ſpirit of wine from it, till the ſalt be ſufficiently ſaturated with its ſulphur, and till it ſuffers the liquor to be drawn off as ſtrong as it was poured on) when the ſalt of tartar, from which it is diſtilled, hath retained or deprived it of the ſulphureous parts of the ſpirit of wine, the reſt, which is incomparably the greateſt part of the liquor, will turn to phlegm.

'Corroſive ſpirits, ſays Mr. *Boyle*, abound 'in water; which may be obſerved, by entangling and ſo fixing their ſaline parts, as to 'make them corrode ſome proper body; or 'elſe, by mortifying them with ſome contrary ſalt, which will turn them into phlegm.' *Boyle*'s *Scept. Chemiſt.*

oils

*Oils* run in great meaſure into water; and, 'tis probable, might be converted wholly into the ſame †.

If this be true, it ſhould ſeem that earth alone is unchangeable; and that water is the matter whereof all things are compoſed: whence ſome philoſophers deduce the reaſon of the *Latin* name *Aquâ*. But the truth is, we have not experiments ſufficient to warrant ſuch concluſion; pure, elementary water being wanting to make experiments upon.

## *Fluidity of* Water.

WATER is fluid; but this fluidity is not natural thereto, but extraneous and violent. For, naturally, it is of the cryſtalline kind; *Water naturally firm.* and accordingly, wherever a certain degree of fire is wanting, there we ſee the water become ice *. That this ice is the proper effect of the want of heat, and not of any additional ſpicula introduced into the water, as *Mariotte* and others contend, is evident enough, were it only hence, that on this ſuppoſition it could not penetrate the ſubſtance of all bodies, as we find it does, and even that of metals.

This water, in its ſtate of ſolution, never remains at reſt: Its parts *Always in motion.* are in perpetual motion; as was firſt diſcovered by the *French*, with the help of microſcopes; and is further confirmed from this, that if a little *Argued from ſolutions,* ſaffron be ſuſpended in the middle of a veſſel full of water, the ſaffron colour will, in a little time, form, as it were, a kind of atmoſphere around, and at length be diffuſed thro' the whole water. Now this could no way be effected without a motion of the watery particles

† 'Tis ſurprizing to obſerve, how great a ſhare of water goes to make up ſeveral bodies, whoſe forms promiſe nothing near ſo much: Eels, by diſtillation, yielded me ſome oil, ſpirit, and volatile ſalt, beſides the *caput mortuum*; yet all theſe were ſo diſproportionate to the phlegm, that they ſeemed to have been nothing but that coagulated; which, likewiſe, ſtrangely abounds in vipers, tho they are eſteemed very hot in operation, and will, in a convenient air, ſurvive, for ſome days, the loſs of their heads and hearts. Human blood it ſelf, as ſpirituous and elaborate a liquor as 'tis reputed, ſo abounds in phlegm, that diſtilling ſome of it, on purpoſe to try the experiment, out of about ſeven ounces and an half, we drew near ſix of phlegm, before any of theſe operative principles began to riſe.' *Boyle's Scept. Chemiſt.*

* Thus Mr. *Boyle*: 'Ice is uſually ſaid to be water brought into a preternatural ſtate by cold; but with regard to the nature of things, and ſetting aſide our arbitrary ideas, it might full as juſtly be ſaid that water is ice preternaturally thawed by heat. If it be urged that ice, left to it ſelf, will, upon the removal of the freezing agents, return to water; it may be anſwered, That not to mention the ſnow and ice which lie all the ſummer long on the *Alps* and other high mountains, even in the torrid zone, we have been aſſured that in ſome parts of *Siberia* the ſurface of the ground continues more months of the year frozen by the natural temperature of the climate, than thawed by the heat of the ſun; and that a little below the ſurface of the ground, the water which chances to be lodged in the cavities of the ſoil, continues in a ſtate of ice all the year round: ſo that when in the heat of ſummer the fields are covered with corn, if you dig a foot or two deep, you ſhall find ice and a frozen ſoil.' *Natural and preternatural ſtate of bodies.*

among each other. Add, that if you caſt a quantity of the drieſt ſalt, in the coldeſt weather, into water, it will ſoon be diſſolved; which argues the continual motion of the particles of that element ||.

*The microſcope.* I have more than once filled a large, wide veſſel with water, and narrowly watched it with a good microſcope; but never could perceive it without ſome ſort of undulatory motion.

*Specific gravity of water perpetually varying.* Water ſcarce ever continues two moments exactly of the ſame weight, but is always varying more or leſs, by reaſon of the air and fire contained in it: thus, if you lay a piece of pure limpid ice in a nice balance, you will never find it continue in æquilibrio. The expanſion of water in boiling, ſhews what effect the different degree of fire has on the gravity of water.

This uncertainty makes it difficult to fix the ſpecific gravity of water, in order to ſettle its degree of purity: but this we may ſay in the general, that the pureſt water we can procure, is that which weighs 880 times as much as air. However, neither have we any tolerable ſtandard in air; for water being ſo much heavier than air, the more water is contained in air, the heavier of courſe muſt it be: as, in effect, the principal part of the weight of the atmoſphere ſeems to ariſe from the water.

*The pureſt natural water, Rain.* Of all waters, the pureſt is that which falls in *rain*, in a cold ſeaſon, and a ſtill sky; and this we muſt be contented to take for elementary water. The rain-water in ſummer, or when the atmoſphere is in commotion, 'tis certain muſt contain infinite kinds of heterogeneous matter: Thus if you gather the water that falls after a thunder-clap, in a ſultry ſummer's day, and let it ſtand and ſettle, you will find a real ſalt ſticking at bottom. But in winter, eſpecially when it freezes, the exhalations are but few; ſo that the rain falls without much adulteration: And hence, what is thus gathered, in the morning time, is found of good uſe for taking away ſpots in the face; and that gathered from ſnow, againſt inflammations of the eyes. Yet this rain-water, with all its purity, may be filtred and diſtilled a thouſand times, and it will ſtill leave ſome fæces behind it; ſo that to procure the pureſt water poſſible, a man muſt look for it in a large, ſpacious plain, in the winter time, when the earth is covered with ſnow, and its pores locked up with froſt.

*Then ſpring-water.* The next, in point of purity, is *ſpring-water:* This, according to Dr. *Halley*, is collected from the air it ſelf; which being ſaturated with water, and coming to be condenſed by the evening's cold, is driven

|| Theſe inſtances of the ſolution of ſalts in water may be accounted for on Sir *Iſaac Newton*'s principles, without ſuppoſing the particles of the fluid in continual motion. True, to effect a ſolution, there muſt firſt be motion; but that motion need not be ſuppoſed to have exiſted before the application of the ſalt to the water. It may have aroſe from the mutual attraction between the particles of the water, and the ſalt; which being ſtronger than that between the particles of the ſalt, may induce a ſeparation thereof, and occaſion them to recede from each other, and diffuſe themſelves throughout the water.

againſt

againſt the cold tops of mountains; where being further condenſed and collected, it gleets down, or diſtills, much as in an alembic. This water, which before floated in the atmoſphere in form of vapour, being thus brought together, at firſt forms little ſtreams, ſeveral of which meeting together form rivulets, and theſe, at length, *rivers*. *River-water.*

If ſuch water chances to flow over ſtrata, or beds, wherein there is ſalt, or ſulphur, or vitriol, or iron, or copper, or the like; the water becomes medicinal: but the baſis, it may ſtill be obſerved, is rain-water *. *Mineral-water.*

Spring-water becomes the better by running; for during all its courſe, it is depoſiting what heterogenous matters it contained. And hence the antient poets and painters repreſent the deities of ſprings and rivers, as combing or carding their waters. They alſo paint them as holding an inclined urn, or veſſel, out of which the water continually flows. Hence *Virgil*:

> *Pocula ſunt fontes liquidi, aut exercita curſu*
> *Flumina.*———

For while the river drives on its waters in an uninterrupted ſtream; all its ſalts, with all the vegetable and animal matters drained into it, either from exhalations, or from the ground it waſhes, gradually, either ſink to the bottom, or are driven to the ſhore.

However, as there is ſtill found ſea-weed, with ſnails, toads, and other animals, in rivers; it follows, that river-water is not ſo pure as that of ſprings †.

But what water deſcends from ſprings, on the tops of mountains, is generally pretty free from heterogeneous bodies; and as ſuch, is much commended by the antients as conducing to long life: *Herodotus* relates, that ſome people drank a water which was ſo very light, that all woods immerged in it immediately ſunk to the bottom; and *Hippocrates* himſelf,

* 'Some ſprings are much more copiouſly 'impregnated than others; and therefore will 'bear a greater dilution by rain-water: Thus, 'tho I have found more than one of our '*Engliſh* ferruginous ſprings, eſpecially thoſe 'near *London*, too much weakened by water 'that rained into them; yet upon carefully 'trying how much of that fluid ſome *German* 'ſpaw-water, which came very well condi'tioned to *London*, would bear, it appeared, 'that when this was diluted with no leſs than 'thrice its weight of rain-water, it ſtill re'tained ſtrength enough to produce a purpliſh 'colour, with freſh powder galls.' *Boyle's Nat. Hiſt. of Mineral Waters.*

† 'That the *Thames*-water, when car'ried long voyages, and into hot climates, 'will have a very offenſive ſcent; the com'mon putrefaction of ſtagnant water may 'perſuade us: yet 'tis found, if that be kept 'long enough, tho in the ſame veſſel, and 'a hotter climate; it will at length grow 'ſweet and potable again. Several other 'waters have the ſame faculty of recovering 'after putrefaction, as well as that of the '*Thames*, whereto 'tis uſually ſuppoſed pecu'liar. And having had the curioſity to try 'how the rougher kind of water, that will 'not bear ſoap, might be remedied; an in'duſtrious perſon, whom I employed, aſſured 'me he had met with pump-waters, that barely 'by ſtanding a few days, would gain this pro'perty.' *Boyle's Uſefulneſs of Exper. Philoſ.*

ſelf, in his treatiſe *de Aere, Aqua & Locis*, obſerves, that the lighteſt water is the beſt †.

The pureſt water we can any way procure, is that diſtilled from ſnow, gathered in a clear, ſtill, pinching night, in ſome very high place; taking none but juſt the outer or ſuperficial part thereof: by a number of repeated diſtillations hereof, you will ſeparate the greateſt part of the earth, and other fæces, and thus have a pure water.

*Water always yields earth, and ſuppoſed convertible into it.*

However, water can never be diſtilled ſo perfectly, as to have nothing heterogeneous therein: Mr. *Boyle* relates, that a friend of his diſtilled a quantity thereof an hundred times; who found at length, that he had got $\frac{6}{10}$ths of the quantity of water, in earth. Hence he concludes that the whole water might, by further proſecuting the ope-

† Phyſicians generally ſuppoſe the light and pure water the moſt wholeſome; ſo that an eaſy contrivance to know when water has theſe properties, would be of ſervice. We have been told, that water brought out of *Africa* into *England* was found, by common ſcales, to be ſpecifically lighter than ours, by four ounces in the pint. Thus many kinds of pump-water will not bear ſoap, and ſome will not dye ſcarlet or other particular colours.

Dr. *Hook* has contrived a water-poiſe, which may be of good ſervice in examining the purity, *&c.* of water: It conſiſts of a round glaſs ball, like a bolt-head, about three inches in diameter, with a narrow ſtem or neck $\frac{1}{24}$th of an inch; which being poiſed with red-lead, ſo as to make it but little heavier than a pure, ſweet water, and thus fitted to one end of a fine balance, with a counter-poiſe at the other; upon the leaſt addition of even $\frac{1}{2000}$th part of ſalt to a quantity of water, half an inch of the neck will emerge above the water, more than did before. *Philoſ. Tranſ.* N° 197.

It is generally granted, that thoſe waters, *cæteris paribus*, are the beſt, as well for wholeſomeneſs as other various œconomical uſes, *&c.* that are freeſt from ſaltneſs; which is an adventitious, and in moſt caſes a hurtful quality in waters. Mr. *Boyle* therefore contrived a very extraordinary method of examining the freſhneſs and ſaltneſs of waters by a precipitant, which could diſcover one part of ſalt in 1000, nay, 2 or 3000 parts of water. This he proved before King *Charles* II. but he was enjoined to keep it a ſecret. *Ibid.*

‘ I have often found an unſuſpected ſea-‘ ſalt in water, by pouring thereinto a ſo-‘ lution of fine ſilver, made in *aqua fortis*: ‘ for as common ſalt, or its ſpirit, will preci-‘ pitate the metal in form of a white calx, ‘ in ſuch a ſolution; I imagined, if the water ‘ in its paſſage thro' the earth, gained ever ‘ ſo few ſaline corpuſcles, they would act, tho ‘ faintly, upon the diſſolved particles of ſilver: ‘ and accordingly, upon their mixture, a kind ‘ of whiteneſs immediately enſued. This ex-‘ periment has taught me to avoid ſuch wa-‘ ter, and to uſe in its ſtead rain-water, or ‘ that which had been freed from its ſalt by ‘ gentle diſtillation.’ *Boyle's Uſeful. of Exper. Philoſ.*

Divers means have been attempted for making ſea-water ſweet: *M. Hauton* had a ſecret for this purpoſe, which he at length diſcovered in the Hiſtory of the Royal Academy. It conſiſted in firſt precipitating the water with oil of tartar, then diſtilling, and laſtly, filtrating it thro' a peculiar ſort of earth, which he mixes with it, and ſuffers to ſettle to the bottom. After theſe three operations, the water remains perfectly wholeſome.

Dr. *Liſter* holds, that ſalt-water is rendered freſh by the breath of plants growing in it; and accordingly gives us an experiment wherein ſome common ſea-weed, or *alga marina*, being ſet in a glaſs body of ſalt-water, diſtilled every day, without any fire, a quantity of pure potable water. *Philoſ. Tranſ.* N° 156.

The thawed ice of ſea-water is often uſed in *Amſterdam* for brewing. And *Bartholine*, in his book *de nivis uſu*, confirms this relation in the following words: ‘ 'Tis certain, ‘ *ſays he*, that if the ice of the ſea-water be ‘ thawed, it loſes its ſaltneſs; as has been ‘ lately tried by a profeſſor in our univerſity.’

ration,

ration, be converted into earth *. But it ſhould be conſidered, that the water can never be removed or poured into any veſſel, without the mixture of ſome duſt therewith: ſo, neither can the luting of the veſſel be diſtilled without loſing ſomething every time. I ſhould rather conclude, therefore, that the water thus often diſtilled, acquired ſtill new earth from the duſt continually floating in the air. This duſt appears very ſenſibly in a dark place, where, after we have ſtaid a-while without any motion, or the leaſt wind to raiſe a duſt, upon admitting a ray or two of the ſun thro' a little aperture, we ſhall perceive the air ſwarm with legions of floating particles of duſt: The like may be concluded from a black cloth; which, tho expoſed in the ſtilleſt place, ſhall ſoon be covered over with thick duſt. *Without ſufficient grounds.*

I have taken ſome of the water, mentioned above, to have been gathered on the turret of the academy; and after diſtilling it by a gentle fire, for the ſpace of four months, it has appeared perfectly pure; and yet, leaving it to reſt in veſſels exactly cloſed, it would conceive a ſlender kind of weedy-matter, ſomewhat like the ſtamina of plants, or the little tufts of a mucilage.

And yet a *Roman* chemiſt ſhutting up a quantity of pure water, in a veſſel ſealed hermetically, *Schottus*, who ſaw it in *Kircher*'s *Muſæum*, after it had been ſo kept upwards of fifty years, affirms that it ſtill remained clear and pure, and ſtood to the ſame height in the veſſel as at firſt, and had not the leaſt ſediment at bottom †.

Chemical

* This inſtance of the convertibility of water into earth, is ſo conſiderable, that it may deſerve to be delivered more at large: The author relates, 'That having put a 'conſiderable quantity of diſtilled rain-water 'into a clean glaſs body, and fitted it with 'a head and receiver, he ſuffered it to ſtand 'in a digeſtive furnace, till by the gentle 'heat thereof, the water was totally ab'ſtracted, and the veſſel left dry; when 'being taken out of the ſand, he found the 'bottom of the glaſs wholly covered with 'a whitiſh ſubſtance; which being ſcraped 'off with a knife, appeared to be a fine 'earth, without any manifeſt taſte.— This 'encouraged him to diſtil the rain-water a'gain, in the ſame glaſs body; in the bot'tom whereof, when the water was all drawn 'off, lay more of the like earth, which con'firmed his conjecture, that the earthy powder 'might be a tranſmutation of ſome parts of 'the water into that ſubſtance. Herein he 'was farther encouraged by a phyſician, who 'aſſured him, that he had frequently found 'ſuch white earth in rain-water, after diſtil'ling the ſame many times ſucceſſively; ad'ding, that he found no cauſe to ſuſpect, that 'if he had continued to re-diſtil the ſame por'tion of water, it would have yielded him 'more earth. Laſtly, a very ingenious per'ſon, who had tried various experiments on 'rain-water, put him beyond all doubts about 'this tranſmutation: for he ſolemnly af'firmed, on experience, that rain-water, even 'after diſtillation in very clean glaſſes, near 'two hundred times, afforded him this white 'earth, and that more conſpicuouſly in the 'latter diſtillations than in the former.' *Boyle of Forms and Qualities.*

† 'Tis diſputed whether or no water be convertible into air. In the vapours daily raiſed, we find water rarefied to a great degree, ſo as to take place in the atmoſphere, and help to compoſe a conſiderable part of what we call air; and even to contribute to many of the effects aſcribed to the air: But ſuch vapour-air has not the characters of true permanent air, being eaſily reducible into water again. So, in digeſtions and diſtillations, tho water may be rarified into vapours, yet it is not really changed into air, but only divided by heat, and diffuſed into very minute parts;

 which

*Differences in water diversify the effect of chemical operations.*

Chemical operations succeed differently, according to the difference of water: We frequently observe a surprizing diversity in the effect of the same operation, conducted after the very same manner; which not being otherwise accountable for, has given many a handle to call the experiments in question. But it is my opinion, that the difference of the water, used by the different operators, may be one great cause of that variation: thus, if you use water gathered in a place where the air is very cloudy, the great number of foreign bodies thence imbibed into the water, may make a great alteration in the effect of the experiment. So pure water, void of salts, is best for producing the *arbor dianæ*; and if you attempt to make it with a water impregnated with salts, the experiment will not succeed: And hence it is, that many chemists held this tree a chemical non entity. The water of *Leyden*, being replete with a vitriolic alum, discharged into the same from the dyers vessels, we have already observed, is much better for dying of scarlet than the waters of *Haerlem*, *Delpht*, *Amsterdam*, or any other place in the same country. Add, that the water gathered in pits, near stables, *&c.* becoming nitrous, excells all others for fertilizing the ground; tho the same circumstance renders them the less proper for numerous other operations.

## *Penetrability of* Water.

*Water the most subtle and penetrative of all bodies except fire.*

WATER is the most penetrative of all bodies, next after fire; for which reason, it is very difficult to confine it: insomuch, that a vessel, thro' which water cannot pass, may retain any thing. Nor is it any objection, that syrups and oils will sometimes pass thro' vessels which water cannot pass; for this is not owing to the greater subtlety, or penetration of their particles, but to this, that such vessels are made of wood wherein rosin abounds, to which oils and syrups are menstruums; so that dissolving the resin, they make their way thro' the

which meeting together, presently return to such water as they constituted before.

Water rarified into vapour in an eolipyle, will, for a while, have an elastic power, like that of air, and be driven out in a stream much resembling air; but the elastic power of this stream is manifestly owing to nothing else but the heat that expands and agitates the aqueous particles thereof; and when that heat is gone, the elasticity and other aerial properties disappear likewise. Rapid winds thus made, seem to be no more than mere water broke into little parts, and put into motion; since by holding a solid, smooth, and close body against it, the vapours condensing thereon, will presently cover the body with water.

'Tho no heat intervenes, says Mr. *Boyle*, 'perhaps motion alone, if vehement, may 'suffice to break water into minute parts, and 'make them ascend upwards, if they cannot, 'otherwise, more easily continue their agita-'tion: For, I remember, that betwixt *Lyons* 'and *Geneva*, where the *Rhone* is suddenly 'straitned by two rocks, exceedingly near each 'other, that rapid stream, dashing with great 'impetuosity against them, breaks part of its 'water into such minute corpuscles, and gives 'it such a motion, that a mist, as it were, may 'be observed at a considerable distance, 'arising from the place, and ascending high 'into the air.' *Phys. Mechan. Exper.*

ſpaces left thereby. Whereas water, as does not act on reſins, is retained in theſe veſſels.

*Pierceso wods, metals, and gold itſelf.* Water, however, does gradually make its way thro' all woods, and is only retainable in glaſs and metals: nay, it was found by experiment at *Florence*, that water ſhut up in a ſpherical veſſel of gold, and then preſſed with a great force, made its way thro' the pores even of gold: So that the moſt ſolid body in nature, is permeable to water.

*Water more in a fluid than air.* Water is even more fluid than air; for we account a body is more fluid than another when its parts will make their way thro' ſmaller pores: Now air, 'tis known, will not paſs thro' leather, as is evident by covering an exhauſted receiver therewith; but water goes thro' it with eaſe. Again, air may be retained in a bladder; whereas water oozes thro' *. In effect, 'tis found that water will paſs thro' pores ten times ſmaller than air will.

All that has been ſaid of air, with regard to the compoſition of bodies, holds much more of water; as being both more penetrative and more ponderous. It enters the compoſition, therefore, of all bodies, both vegetables, animals and foſſils; and has this circumſtance peculiar to it, that it is eaſily ſeparable from any of the bodies it unites withal; which cannot be ſaid of any other body. Fire, indeed, will penetrate more than water; but then it is difficult to ſeparate it again from the bodies it is once fixed in; as is evident in red-lead, &c.

*A proper vehicle of nutriment.* This property of water, joined with its ſmoothneſs and lubricity, renders it fit to ſerve as a vehicle, for the commodious and eaſy conveyance of the nutritious matter of all bodies: for in being ſo very fluid, and paſſing and re-paſſing ſo readily, it never ſtops up the pores, but leaves room for the following water to bring on a new ſupply of nutritious matter.

## Water *renders many bodies ſolid and hard.*

IT has been obſerved, that water does not adhere to bodies with a lentor or viſcidity; as is the caſe in alcohol, oil, or the like bodies: thus it rarely leaves any ſtriæ on glaſs, nor is it to be drawn into ſtriæ; but it eaſily unites with them, and is eaſily parted from them: Ordinarily it is even ſeparable from them by a gentle degree of heat; except from ſuch as imbibe it, as ſalt of tartar, oil of vitriol, &c. from which it is not ſeparable without great difficulty. And yet the ſame water will cohere firmly with many matters, and bind them together,

* *M. Homberg* is of opinion, that water enters ſuch narrow pores of animal ſubſtances, as will not admit the air, only becauſe it moiſtens and diſſolves the glutinous matter of the fine fibres of the membranes; and alſo renders them more pliable and diſtractile; which are things that the air, for want of a wetting property, cannot do. As a proof of this doctrine, he filled a bladder with air, and compreſſed it with a ſtone, and found no air to come out: but placing the bladder, thus compreſſed in water, that air eaſily eſcaped. *Hiſt. de l' Acad. Ann.* 1700. *p.* 45.

ſo

ſo as to form them into the moſt ſolid bodies. Tho it will appear very wonderful, that water, which is, as it were, an univerſal diſſolvent, ſhould withal be a great coagulator.

*Water cements, or binds together the parts of many bodies, as wood.*

Thus water mixed up with earth or aſhes, gives them the utmoſt firmneſs and fixity: The aſhes, for inſtance, of an animal, well incorporated with pure water, and made into a paſte; and this baked by a vehement fire, grow into a cupel which ſhall bear the utmoſt effort of the refiner's furnace. 'Tis by water alone that our houſes ſtand: for take the water out of wood, and it becomes aſhes; or out of tyles, and they become mere duſt.

*Tyles.*

*Potters-ware.*

Thus a little clay, dried in the ſun, becomes a powder; which powder being mixed with water, ſticks again together; ſo that you may faſhion it at pleaſure: and this, dried again by a gentle fire, or in the ſun, and then baked in a potter's oven by an intenſe fire, becomes little other than a ſtone. Which is what mere water alone does; oil will not do it.

*Porcelain.*

So the *Chineſe* or *Japan* earth whereof our porcelain veſſels are made, which hold all liquors, and even melted lead it ſelf, is diluted and wrought up with water. In effect, all the ſtability and firmneſs that is ſeen in the univerſe is owing to water alone: thus ſtone would be an incoherent ſand, did not water bind it together.

*Stone.*

*Bricks.*

Thus, again, of a fat, gravelly earth, wrought up with water, and baked or burnt, we make bricks, tyles, and earthen veſſels, of ſuch exceeding hardneſs and cloſeneſs, that water cannot paſs thro' them. And theſe bodies, tho to appearance perfectly dry and deſtitute of water; yet, if they be pulverized and put in a retort, and diſtilled, yield an incredible quantity of water: Whence it appears, that the particles of water may be ſo diffuſed, and diſperſed thro' bodies, as to cohere with them, and give them hardneſs (for the particles of ſand would never ſtick together without water) and yet may be fetched back again, and reduced to their former fluid ſtate. And the ſame holds of metal; for the parings or filings of lead, tin, antimony, *&c.* by diſtillation, yield water very plentifully: And the hardeſt ſtones, ſea-ſalt, nitre, vitriol, ſulphur, *&c.* are found to conſiſt chiefly of water, into which they reſolve by force of fire, and loſe the coheſion of their parts. Thus if you diſtil ſal gemmæ, which is a very hard tranſparent body, like cryſtal, a good quantity of water will ariſe; and then the body, which before was tranſparent, becomes opake, white, and friable.

*Metals.*

*Salts.*

*Limeſtone.*

The *lapis calcarius*, or lime-ſtone, being expoſed to the fire, affords a prodigious quantity of pure water; and the more of this water is expreſſed, the more friable does it become, till at length it commences a dry calx or lime; wherein, in lieu of the water ſo expelled, the fire, in the courſe of calcination, enters; which is expelled again, in its turn, by pouring on cold water. Laſtly, of the water and calx tempered together, ariſes a maſs, ſcarce inferior, in point of ſolidity, to the primitive lime-ſtone. So that the *lapis calcarius* appears to be no more than limy-earth, bound into a hard ſubſtance by water.

*Mortar.*

From

From what has been ſaid, it appears, that water is the univerſal gluten, which binds together the parts of all bodies: And hence that obſervation of *Centivoglio*, Nature makes diamonds of a water well depurated and harden'd into a maſs.

## Water *not elaſtic.*

THAT *water* is not elaſtic, is evident hence, that it is incompreſſible, or incapable, by any means, of being reduced into leſs compaſs, tho urged with the greateſt weight: this we learn from that famous experiment made by order of the great duke of *Tuſcany*; where a quantity of water being cloſely included in a hollow ball of pure gold, and thus laid in a preſs, with a prodigious force thereon; the ball not being able to aſſume a more copious figure, to give more room for the water; and the water being incapable of condenſation; rather than yield, it tranſuded thro' the pores of the metal; ſo that the ball was found wet all over on the outſide. Till, at length, making a cleft in the gold, it ſpun out with great vehemence: from which circumſtance, ſome have concluded that it was elaſtic; but on weak grounds; the impetus wherewith the water darted out, being more probably owing to the elaſtic force of the gold, which communicated that impreſſion to the water. *Water incompreſſible and unelaſtic.* *Forced thro' gold.*

And hence we ſee the reaſon why blocks of marble ſometimes burſt in cold weather; and why water which has once filled a concave body, that afterwards, by any means, comes to be reduced into leſs compaſs, burſts the veſſel, tho ever ſo ſtrong. This is very obſervable in a piece of braſs canon; which being filled with water, and the mouth exactly ſtopped ſo as to prevent all egreſs of water: If a cold night happens, ſufficient to contract and conſtipate bodies; the metallic matter undergoing the common fate, and the water refuſing to give way, the canon is burſt aſunder with incredible violence. Tho others account for the effect from this, that the included water, in freezing, endeavours to expand it ſelf, or poſſeſs more room than before; which being denied, it burſts thro' its reſtraint. *Burſts blocks of marble, braſs canons, &c.*

Some bring an argument for the elaſticity of water hence, that hot water takes up more room than cold: But no legitimate concluſion can be formed hence; for in the hot water there is a good quantity of fire contained, which interpoſing between the particles of the water, makes it extend to a greater ſpace, without any expanſion of parts from its own elaſticity. This is evident hence, that if water be once heated, there is no reducing it to its former dimenſions, but by letting it cool again; which plainly ſhews, that the expanſion depends not on the elaſticity of the parts, but on the preſence of fire. Water then, tho incapable of compreſſion or condenſation, may yet be rarified by heat, and *Water expands by heat, and why.*

contracted by cold*. So that fire may act on some bodies that are not elastic.

If it be asked, how it happens that a body so light, fluid, and volatile, and which so easy a fire suffices to rarify, should be so stubborn and incompressible? we see no other cause to assign, but the homogeneity of its parts. If water be considered as consisting of spherical, or cubical particles, hollow withinside, and of a firm texture, here will be enough to account for the whole. Its firmness and similarity will make it resist sufficiently; and its vacuity render it light enough, &c.

## *Properties of the Particles of* Water.

FROM what has been said, we may settle something as to the nature of the component particles of *water*: And,

*The particles of water are extremely small.* 1°, The particles whereof water consists, are, as to our senses, infinitely small; as appears from their prodigious penetrative power.

*Smooth.* 2°, They are exceedingly smooth and slippery, void of any sensible asperities; as appears from their being so easily separable from other bodies they adhere to.

*Solid.* 3°, They are extremely solid; as appears from their cohering with other bodies into a solid form.

*Transparent and invisible.* 4°, They are perfectly transparent, and, as such, invisible: This we gather, 1°, From hence, that pure water inclosed in a clean vessel hermetically sealed, projects no shadow; so that the eye shall not be able

* It may be added, that a further degree of cold, that is, such a one as congeals water, or turns it into ice, does expand it. There are other ways to manifest this expansion of water by freezing: Mr. *Boyle* having poured a proper quantity of water into a strong cylindrical earthen vessel, he exposed it, uncovered, both to the open air in frosty nights, and the operation of snow and salt; and found that the ice produced in both cases, reached higher than the water before 'twas froze.

So if a concave cylinder, made of any compact matter, be tightly stopped at one end with wax, and filled with water at the other, and then that also be closed in the same manner; if, I say, this pipe be suspended in the air sufficiently cold, the contained water will be froze, and the stopples at both ends, or at least at one, will be thrown out; and a rod of ice appear thereat, in continuation with the tube.

A Stonecutter complained to Mr *Boyle*, that sometimes, thro' the negligence of the servants, the rain being suffered to soak into marble, the violent frosts coming on, would burst the stones. And another tradesman complained, that even implements made of bell-metal, being carelesly exposed to the wet, have been broken and spoiled by the water; which having entred at the little cavities of the metal, was there afterwards froze, and expanded into ice. And *Cabeus* tells us, that he saw a huge vessel, of exceeding hard metal, split asunder by congealed water.

*Busbequius* relates, 'That at *Constantinople* 'a monstrous obelisk, thrown from its pedestal 'in the city, had remained at its length for 'many ages; till in later times an architect 'appeared, who for a certain sum undertook 'to set it again upon its base; and having to 'this end prepared abundance of machines, 'he therewith raised it within an inch of its 'due height; then throwing water on the 'ropes that supported the pillar, they gradually 'contracted and set it upon its base.' To render this the more credible, the like is mentioned by many eminent authors, as having been elsewhere practised; and the thing is allowed of by *Galilæo*.

to discover whether the vessel have water in it or not. 2°, In that the crystals of salts, when the water is separated from them, lose their transparency.

5°, They are very rigid and inflexible; as appears from their not being compressible: *Des Cartes* supposed the particles of water of an eel-like form, to account for their lubricity; but, on this footing, they could not be incompressible. *Rigid.*

It is observed, that when salt is infused in water, it does not fill the vessel in proportion to its own bulk; whence it follows, that there must be some little spaces between its particles, to admit those of the salt. And hence again we gather, that the watry particles are solid and inflexible; since, tho they have intermediate spaces, yet no force or weight can any way compress or croud them nearer together.

From the whole it follows, that water, devoid of any heterogeneous admixture, consists of exceedingly minute, penetrative, fluid, slippery, solid, ponderous particles; and consequently, approaches near to the nature of mercury: And hence that observation of the antient chemists, *That mercury is the only body in nature that dissolves*; alluding to the menstruous virtue of water.

## Water *insipid and inodorous.*

WATER is the most insipid of all bodies; for the taste we sometimes observe therein, does not arise from the mere water, but from some salt, vitriol, or other bodies mixed with it: And accordingly, all the waters that are savoury, as those of *Italy*, &c. and which are recommended by the physicians for medicinal uses, are always found to deposit a quantity of some of these fossils. *Water void of taste.*

Nor does it appear, by any experiment, that water has the least smell; provided it be pure; so that water might remain imperceptible to us were it not for our sense of touching. *And smell.*

Water, therefore, appears to be perfectly indifferent as to the assuming of all forms: *Centivoglio* maintains, that if it happen to fall in a place where there is, *e. g.* pure cinnabar, or any other matter, the water will join with them all, and become what they are: which opinion falls in with that of *Thales* and *Paracelsus* above-mentioned *. And hence it is, that water is called a *second mercury*.

* 'All birds, beasts, and fishes, insects, 'trees and vegetables, with their several parts, 'grow out of water, and watry tinctures and 'salts; and by putrefaction, return again into 'watry substances. Water, standing a few 'days in the open air, yields a tincture; 'which (like that of malt) by standing longer, 'yields a sediment, and a spirit; but before 'putrefaction, is fit nourishment for animals 'and vegetables. And, among such various 'and strange transmutations, why may not 'nature change bodies into light, and light 'into bodies.' *Newton's Opticks, p.* 349, 350.

## *The solutive Power of* Water.

*Water the only dissolvent of salts.*

FOR what relates to *water*, considered as a menstruum; it dissolves, 1°, All salts, as sugar, borax, *&c.* which air only dissolves in virtue of the water it contains; which fire only liquifies, and earth leaves untouched: so that water alone is the proper menstruum of salts.

The particles of salts, we have observed, can insinuate themselves into the interstices between the particles of water; but when those interstices are filled with any salt, the same water will not any longer dissolve the same salt: but a salt of another kind it will; by reason its particles, being of a different form, will enter and occupy the vacancies left by the former: And thus, again, it will dissolve a third or fourth salt, *&c.* So when water has imbibed its fill of common salt, it will still dissolve nitre; and when saturated with that, it will dissolve sal-ammoniac, and so on.

*And of saline bodies.*

2°, It dissolves all saline bodies; it being the constituent character of a saline body, to be uninflammable, and dissoluble in water. Hence water may dissolve all bodies, even the heaviest and most compact, as metals; inasmuch as those are capable of being reduced into a saline form: for these may be so intimately dissolved by water, as to be sustained therein.

*Of saponaceous bodies.*

3°, It dissolves all saponaceous bodies, *i. e.* all alcalious salts, and oils blended together: Those two bodies make a sapa, which is a saline body, but not a salt. Now oil it self is not dissoluble in water, but the admixture of the salt here, rendering it saline, water readily dissolves it.

All the humours in the human body, are apparently saline, tho none of them are salt it self. The same may be said of the juices of all vegetables, excepting the oils; which, accordingly, dissolve in water.

Salts are the active instruments of nature; and yet these do not act unless dissolved either by water or fire.

A crystal is a glebe of salt, or metal, or both together: If now you take sea-salt, well dried, it will be white, and not transparent; dissolve it in water, and after exhaling the water, it will become transparent, by reason of the water interposed between its parts.

*Dissolves glass.*

4°, It dissolves glass it self; for this, if melted with salt of tartar, becomes soluble in water.

*And gums.*

5°, It dissolves all gummous bodies; this being part of the definition of a gum, that it dissolves in water; in contradistinction from a resin.

*Does not dissolve oils, or oleaginous bodies.*

But oleaginous bodies it leaves untouched: nay, and what is more extraordinary, it repels them; and by repelling, drives the oily particles into eddies.

If an hundred drops of oil be thrown upon water, all the several drops, which before were perfectly dispersed, will soon gather together again, and leave the water alone; so that there should seem to be some

ſome repugnance between water and oil, and ſome attraction between the particles of water, as alſo between thoſe of oil. Add, that water ſeems to repel all oleaginous, fatty, and adipous bodies wherein oil predominates; and hence alſo it is, that the fatty parts in our bodies eſcape being diſſolved by water. And 'tis, in all probability, by this means that fat is collected in the adipoſe-cells of all animals.

Nor does water diſſolve ſulphur; for tho you boil ſulphur ever ſo long in water, it will ſtill remain untouched. *Nor ſulphur.*

Nor does it diſſolve terrene or earthy bodies, but rather unites and conſolidates them; as we ſee in tyles, *&c.* Water, however, mixed with acali ſalts, diſſolves oils and oily bodies: thus, tho mere water, poured on greaſy wool, be repelled thereby, and contributes nothing towards cleanſing of the ſame; yet mix a ſtrong lixivium, or an alkali ſalt with the water, and it then readily diſſolves and abſorbs all that was greaſy and oleaginous: and thus it is woollen clothes are ſcoured. But neither will water alone do, as being immiſcible with oil; nor will any other ſort of ſalts; for ſea-water, with all its ſalt, will never waſh out any oily impurities. So, in the ordinary methods of ſcouring and fulling, the ſtuffs are waſhed in ſtale, putrified human urine, which is known to be a thorow alkali. *Nor earth.* *Alcali ſalt added to it makes it diſſolve oil, &c.*

Laſtly, it does not diſſolve reſins; as we conceive a reſin to be no other than an inſpiſſated, or concentrated oil. *Does not diſſolve reſins.*

## *Concretion of* Water *into Cryſtals.*

AFTER water has diſſolved a body, it grows, and hardens together with it; and if the body be of the ſaline kind, forms cryſtals, and retains the ſalt in that form. Salts, while thus joined with water, aſſume various figures: the cryſtals of ſea-ſalt, *e. g.* are pyramidal; thoſe of nitre, priſmatical; thoſe of ſal-gemmæ, cubical, *&c.* But, that water is the cauſe of thoſe ſalts being in cryſtals, is evident hence, that upon ſeparating the water, the cryſtals are no more; their form is loſt, and their tranſparency ceaſes. *With ſalts ſhoots into cryſtals.*

## Water *the great inſtrument of fermentation and putrefaction.*

WATER is properly enough denominated the mother of fermentation, as no fermentation can be effected without it. Dry bodies, in effect, never ferment: thus, if you grind a plant into a duſt or *farina*, it will not ferment, even tho you add oil, or ſpirit of wine, thereto: But pour water on it, and, as if you had given it ſome new vital principle, it ſtrait ferments, and produces the deſired effect. *No fermentation without water.*

The inſpiſſated juice of grapes may be kept a long time without fermentation; but if you diſſolve it in water, fermentation ſoon ariſes. So that the requiſites to fermentation, are, 1°, Fire, to actuate. 2°, Air, to vibrate. 3°, Water, to dilute.

In

*Nor putrefaction.*

In like manner, all putrefactions, both of animal and vegetable bodies, are performed by means of water alone; take, *e. g.* a pound of fresh flesh, and keep it in a heat like that of our body, and in a few days the putrefaction will be compleated: but, if you first drain out or exhale all the watry part from the same in some chemical vessel; tho the salt and oil remain; the flesh will harden like a stone, and may be kept for ages without putrefaction. Tho, water poured on it, or even the common dew, will soon set it a putrefying.

By such means, bread, flesh, or the like foods, may be preserved for ages; provided regard be had to the place: Hence it is, that in dry countries, as *Ægypt*, dead carcasses never putrefy, but dry and harden uncorrupted; as we see in the mummies found buried under the sand. Even human blood, which naturally is so prone to putrefaction, if you deprive it of its watry part, may be kept for fifty years: goats blood we actually find kept so long in the shops, without corrupting; tho if you dissolve it in water, and expose it to a gentle warmth, it putrefies immediately. So that air, water, and fire, are required to putrefaction as well as fermentation.

## Water *contributes to effervescencies.*

*Nor effervescence.*

WATER is of absolute necessity to effervescence *, which is an intestine motion arising between contrary salts: now no such motion can arise from a mixture of contrary salts, unless there be water withal: thus sulphur, mixed with steel filings, raises no effervescence, unless water be added; so if you mix acid and alkaline salts together, in a dry form, they will remain without effervescence; excepting such as are themselves impregnated with water, as oil of vitriol and spirit of nitre, which yield water in great abundance. Oil of vitriol is one of our greatest acids, and with a little degree of cold shoots into crystals; tho a gentle fire readily liquifies it again: now, if some of this oil be mixed with a body that has but little water, scarce any effect is seen; but pour on water, and a surprizing effect will be produced.

*Water separates oily from saline bodies.*

Water also serves in making separations of oily parts from saline ones; which is a thing of the utmost service in chemistry: Thus, any oleagenous substance, mixed and incorporated with a deal of salt, if it be

* An experienced *German* chemist relates, that in some parts of his country, he met with vitriol stones, or marcasites, that, by the action of mere common water, resting for a competent time upon them, would grow so hot, as to enable the liquor to retain a sensible heat, when it had passed a pretty way from them. And many accidents may occasion the breaking out of such waters, or the change of their course in the subterraneal places. So, that common water may, in a very short time, produce considerable heat in mineral bodies, appears by mixing two or three pounds of fine powder of common brimstone, with a convenient quantity of filings of iron; for this mixture being drenched with common water, will, in a short time, grow exceedingly hot, and send out a thick smoke, like that of good quick-lime, while slaking with water.

ſhook a good while in a ſufficient quantity of water, the ſalts will be extracted from the oil, and diſſolved and imbibed by the water; and thus the body is dulcified. So butter, by a continued lotion in fair water, becomes inſipid; and aromatic oils agitated a long time in warm water, lay aſide their ſaline, ſpirituous parts, and become inert and inodorous.

'Tis likewiſe by water that acid ſpirits are ſeparated from the bodies diſſolved thereby; particularly metalline ones. Thus a metal being diſſolved in ſome acid ſpirit or other menſtruum; if you mix a quantity of water therewith, the menſtruum becomes weakened thereby, and lets the metal fall to the bottom. So if you pour water on a ſolution of gold in *aqua regia*, and then expoſe it to a moderate fire to evaporate; without melting the cryſtals, it will carry away with it a great part of the acid ſpirit, and leave the gold dulcified. *Separates acid ſpirits from bodies diſſolved therein.*

Water, alone, we have obſerved, has the property of diluting ſalts, and repelling oils: but 'tis by ſalts, that the operations of chemiſtry are chiefly effected; nor can ſalts act unleſs diſſolved: Conſequently water, as it brings ſalts into action, is of the utmoſt importance in chemiſtry. *Great uſes of water.*

To this we owe the ſeparations of ſulphureous and inflammable ſpirits: Alcohol of wine, mixed up with oil, makes one body therewith; but if you pour water thereon, it will repel the oil, and draw all the alcohol to it ſelf. Nay, frequently, what alcohol had diſſolved in other bodies, water will ſeparate therefrom, by attenuating the alcohol, and letting the other matters precipitate to the bottom. *In making ſeparations.*

Water, therefore, contributes to bring forth the active parts of all bodies; as it extracts their ſalts, alcohol, ſpirits, odours and taſtes; which it does without any notable diminution of their powers. Hence water becomes greatly uſeful in making divers extracts, *viz.* by diſſolving the ſaline, ſpirituous, aqueous, ſaponaceous and other matters, and ſeparating them from the reſt of the body. *Bringing forth the active principles of bodies.*

In diſtillation, water is of the utmoſt uſe: It is this that receives the active parts of bodies; and in affording them, as it were, a vehicle, it inſinuates into their pores, ſeparates the oil, and raiſes it on high, without making any ſtench: And thus are the eſſential oils of bodies diſtilled without burning, and without being tainted with that empyreuma which is the conſequence of combuſtion. Thus there would be no procuring, *e. g.* of diſtilled oil of cinnamon, without water; but ſuch as would have an intolerable ſtench. *In diſtillations.*

Salts, and ſaline bodies, by a repeated affuſion of water, are rendered volatile; and even metals are capable of being diſtilled by the ſame means: ſo oil of vitriol, which otherwiſe does not riſe without the moſt vehement fire, yet, being mixed with water, becomes volatile, and yields an excellent acid ſpirit, called by *Helmont*, *Acidum Eſuriens*. *Volatilizations.*

In fine, water ſerves good purpoſes in the dulcifying of bodies: for there are abundance of things to which acrid ſaline matters adhere, *In dulcifying bodies.*

and which are hereby rendered ſharp and acrimonious; but theſe acrimonies may be volatilized by repeated affuſions of water; *i. e.* be diſſolved and carried off; and thus the bodies left freſh and ſweet.

## Water *ſerves for the Direction of Fire.*

*Water of uſe in the management of fire.*

WATER is of great ſervice among the chemiſts, in directing and determining the degree of fire: This was firſt diſcovered by *M. Amontons*, from an obſervation, that water placed over the fire, grows gradually more and more hot, till it comes to boil; but that it then ceaſes to increaſe, and only maintains its preſent degree of heat; even tho the fire were ever ſo much enlarged, or it were continued ever ſo long over it: This, then, is a fixed degree of heat all over the world; boiling water, provided it be equally pure, being of the ſame heat in *Greenland* as under the Equator.

*Divers degrees of heat produc'd thereby.*

By means hereof, therefore, our diſtillations are much more conveniently managed; and we are enabled to make baths of divers degrees of heat, accommodated to the various occaſions: As 1°, A vapour-bath, *balneum vaporis*, where the body to be diſtilled is placed in the ſteam of boiling water. 2°, Dew-bath, *balneum roris*, where the body is likewiſe placed in the ſteam, but ſomewhat nearer to the water than in the former; ſo that the heat is ſomewhat greater. 3°, Sea-bath, *balneum maris*, or, as 'tis vulgarly called, *balneum Mariæ*, where the body to be diſtilled is put in the water it ſelf, and conſequently undergoes a yet further degree of heat than either of the former. 4°, *Balneum ventris equini*, or *fimi equini*, horſe-dung-bath, when a body is laid to digeſt in horſes dung; the heat whereof is managed and directed by water: for as ſoon as the dung dries, it cools; and is reſtored to its former heat by the pouring on hot water. 5°, Hay-bath, *balneum fœni*, when a body is laid to digeſt in moiſt hay, whoſe heat is likewiſe directed by water.

From what has been ſaid, of the ingredients, properties and powers of water, we may eaſily apprehend the reaſon why the antients called it οἶνον καθολικὸν, univerſal wine.

Of

# *Of* EARTH.

THE *earth* we here principally propoſe to conſider, is neither that of the naturaliſts nor the vulgar; but the elementary, or pure virgin earth, allowed for a chemical principle.

The word among the naturaliſts denotes the terraqueous globe; and in agriculture ſignifies that compound matter which ſerves for the production and growth of vegetables planted therein; but the chemical *earth* differs widely from them both, as being *a perfectly homogeneous, or ſimple body, hard, friable, inſoluble in air or water, fixed, and incapable of flowing in the fire, but remaining immutable, and retaining its own form and quantity in them all.* We term it a foſſil, as being exceeding ſimple, or inorganical, without any diſtinction of veſſels and juices; and proceeding originally from the common matter of the terraqueous globe. 'Tis called ſimple, becauſe all its parts appear of the ſame nature with the whole. We define it hard, becauſe it reſiſts the ſeparation of its parts; friable, becauſe it may be broke into leſs maſſes; and fixed in the fire, becauſe with whatever violent degree of heat 'tis every way ſurrounded, it loſes nothing of its weight or bulk, yet without running into glaſs; but poſſibly the focus of a large burning concave, may cauſe ſome alteration therein; tho it would loſe conſiderably leſs than any other body in nature, even gold it ſelf; the moſt violent fire being unable to break the coheſion of its parts, which is a very uncommon property. 'Tis ſo ſimple, that tho it enters the compoſition of all other bodies, yet it ſelf can never be reſolved into any different ſubſtance. *Helmont* tells us, it will reſiſt the force of the *alcaheſt*, which would diſſolve all kinds of metals; and declares it to be the ſimpleſt body in nature next to elementary water; and ſo indeed it appears to be. Theſe properties ſufficiently diſtinguiſh it from all the other bodies we know, whether ſalts, oils, ſulphurs, medicinal earths, metals, &c. Chemical earth, therefore, is a very different thing from ſand, which appears to be a heap of brittle flints, or ſmall tranſparent cryſtals, fuſible by fire, and eaſily convertible into glaſs. Our definition, alſo, ſufficiently diſtinguiſhes this elementary from the mixed or vulgar earth, which contains a large proportion of other foreign matters, as ſand, clay, ſalts, and a mixture of vegetable, animal, and mineral ſubſtances, and is almoſt wholly reducible to ſalt and oil; a ſmall quantity of our philoſophical, or virgin earth, remaining behind.

*Earth, chemical, what.*

*How diſtinguiſhed from other bodies.*

In effect, chemical earth is either the pure and fixed aſhes of all bodies perfectly calcined, or what rain-water leaves behind it upon repeated diſtillation.

That afforded by the diſtillation of water, appears to come out of the air, into which it is raiſed along with the ſmoke, and numerous other

*How obtained,*

parts of vegetable and animal bodies, which fly off in effluvia; for tho this earth be of it felf fo fixed, yet 'tis eafily rendered volatile by fire, when mixed along with other light or vifcid bodies *. Perhaps alfo in Mr. *Boyle*'s method of procuring it by the repeated dtftillation of fair water, which every time leaves a quantity of it upon the fides of the retort employed in the operation, part of it may proceed from the cement of the glaffes, or the duft of the air, which comes in contact with the furface of the water, whilft 'tis poured out of one veffel into another †. And that earth may eafily fly about in the air, feems confirmed by thofe fhowers of fand fo frequent in the defarts of *Arabia*. But the white matter which thus adheres to the glafs, is not pure virgin earth; being faline in tafte, and combuftible in the fire; whence it contains both falt and oil; of which it may be deprived by calcination, and repeated ablutions in frefh water, and reduced to the purity and fimplicity required in chemical principles.

*In vegetables.* Vegetables afford our earth in confiderable quantities by calcination, and repeated ablution, in pure rain-water; whereby 'tis freed from the fand, falt, and other fæces that are apt to adhere to it, till it becomes white, like chalk, perfectly infipid, fmooth and foft upon the tongue, fcentlefs tho thrown upon live coals, unelaftic, or incapable of ringing when ftruck upon, and a fit matter for tefts or cupels, wherein metals will fufe, whilft the containing veffels remain unhurt by the fire: this being perhaps the only fixed matter in nature that will not flow with heat. For which purpofe 'tis mixed up with fair water, or that wherein flefh has firft been boiled, and by moulds fafhioned at the pleafure of the artificer; fuch liquors being free from all fixed falt, afford an excellent glue in this cafe. If lead, or any other metal, except gold and filver, be long kept in fufion, in one of thefe veffels, the metal will be abforbed by it, as a fpunge drinks in water; but filver and gold will never thus enter the pores of the veffel; which, therefore, may be called the myftic fieve of *Vulcan*, or the actual ftrainer of the alchemifts. Thus were a mixture of gold, filver, and any other metals, to be blown off a teft prepared of our virgin earth, the bafer metals would fink into it, and leave the nobler alone behind.

* Mr. *Boyle*, in his curious treatife of *Effluvia*, obferves, that earthy matter may be raifed in a very confiderable quantity into the air; and to this purpofe relates from *Agricola*, an account of a fhower of rain, which covered the ftreets it fell upon with clay.

† The great quantity of earth which Mr. *Boyle* obtained, in proportion to the water diftilled, with the probability there is, that if the operation was often enough repeated, the whole body of the water would be thus converted into earth, renders it impoffible to fuppofe the phænomenon entirely owing to the caufes here fuggefted, as fome have imagined. The fact is much better accounted for by the excellent author himfelf, from the known and allowed effects of fire or fewel, which has the power of making new coalitions of particles in bodies, and thence of introducing new forms: and thus alcohol of wine may be reduced to earth, as well as fimple water, as Mr. *Boyle* has tried. *See his producibleness of chymical principles, under the article* Earth.

After

After the ſame manner may our earth be obtained from the ſoot, or condenſed ſmoke, of vegetables; which is no more than a black volatile coal. This ſoot, or ſmoke, is afforded by all manner of woods, not excepting that employed by the *Romans* before the invention of chimneys. Indeed they diligently ſought for ſuch wood as would ſmoke but little; and perhaps it was ſaid not to ſmoke at all, only becauſe it did not yield a thick, black, ſuffocating ſmoke, offenſive to the eyes and noſe. The earth which ſoot affords by calcination, is perfectly like that obtained from the other parts of vegetables; being carried up from them by the force of the fire, whilſt wrapped up in a viſcous oil, which aſcends together therewith: ſo that hence fire has the power to volatilize fixed earth, and ſend it up into the air; whereof it does not appear to be any original production. Hence the virgin earth obtained from ſnow, hail, dew, *&c.* is very probably no other than what was thus carried up into the atmoſphere, and there mixed with theſe meteors.

Mr. *Boyle* found by experiments purpoſely made, that the eſſential oils of vegetables are almoſt wholly convertible, by repeated diſtillation, into a black, pitchy matter, which by calcination affords a large proportion of elementary earth. And fixed alkaline ſalts, as the ſame great philoſopher has alſo tried, may, by running *per deliquium* in the air, or by repeated ſolutions in water, and ſucceſſive filtrations, be converted into the ſame. Even rectified ſpirit of wine, he obſerves, by repeated diſtillation yields a ſmall proportion of it, and appears in the form of a ſpot on the glaſs, from whence the ſpirit was diſtilled. And in ſhort, all vegetable productions, as diſtilled waters, ſalts of all kinds, oils, ſpirits, *&c.* may be made to afford it.

The ſame may likewiſe be ſaid of animal ſubſtances. Bone-aſhes yield *In animals.* it to great advantage; and from them the aſſay-maſters have the matter for their teſts, as well as from the aſhes of vegetables. The hair alſo of animals, burnt to aſhes in the flame of ſpirit of wine, afford a very pure earth, and exhibit the *ſtamina* entire, after being deprived of the more fluid parts. Thus likewiſe 'tis very obſervable, that when a man dies in a hot climate, and lies expoſed to the open air, his whole carcaſe is conſumed, or carried off into the atmoſphere, in a very few days time; nothing but a mere ſkeleton being left behind, that contains little or no oil or ſalt, but appears a perfect calx, like the pure elementary earth of vegetables, as if it had already been calcined. And thus in church-yards, or burying-vaults, we ſhall ſometimes find the form of an entire ſkeleton, ſound and perfect to appearance, that with the ſlighteſt touch crumbles away, and falls into a kind of duſt, perfectly inſipid and inodorous. Whence we may form ſomewhat of a conjecture, as to the quantity of earth naturally contained in the human body; for little or none of it will be made to fly off by a degree of heat leſs than that of boiling water; as I have found by particular experiments. All the juices, and all the ſeveral parts of animals,

whether soft or hard, may, by distillation, calcination, &c. be brought to afford this earth, in some proportion; and as the earth of animals is always perfectly the same with that of vegetables, the difference between them cannot be at all owing to this principle *.

*And in fossils.* Sea-salt, sal-gem, and all other saline bodies, tho ever so pure, being dissolved in fair water, will, by rest, constantly deposite a terrestrial part, which may be reduced to elementary earth: and, by distillation, likewise they will afford an acid spirit, which lets fall a considerable proportion of the same. Volatile salts also may be made to afford an earth by distillation: thus, for instance, if an ounce of the volatile salt of harts-horn be included in a proper vessel, hermetically sealed, and sublimed with a heat no greater than that of the human body when in health, the saline part will fix itself to the top of the glass, and leave an oil at the bottom, which, by repeated distillations, constantly leaves some quantity of earth behind, till all the volatile part is perfectly gone off, and nothing but elementary earth remains. In short, this earth may, by proper management, be obtained from all sorts of bodies, but with the utmost difficulty, and in very small quantities, from metals; so that some chemists have questioned whether they really contain any at all, tho they freely allow it to other fossils. And, indeed, we want experiments fully to determine this matter †; tho for my own part, I cannot but be of opinion, that earth is that ingredient in the composition of metals, which gives them their fixity, and that durability for which they are principally valued. But it may admit of a doubt, whether this virgin earth is ever obtained perfectly pure and unmixed with oil, salt, and other heterogeneous bodies, from any subject whatever; yet we may certainly gain it much purer than others of the chemical elements. I have now by me the earth of the plant rosemary, which remains perfectly unaltered, after a vast variety of experiments which I purposely made to change it. *Its uses in natural bodies.* This great degree of fixedness and immutability admirably fits our earth for the common basis of all mixed bodies, by fixing their volatile principles, and keeping the whole together under its peculiar form. 'Tis certain that fire, water, vulgar earth, salts, oils, &c. once deprived hereof, become totally volatile and disappear, or spontaneously go off into the air. All salts are fixed merely by the earth they contain; separate them from this, and they will get out of the glasses into which you put them, tho ever so closely stopped

* To render the earths of the subjects of different kingdoms perfectly alike, the operation must be performed with great exactness, and the other principles be perfectly separated from the terrestrial one, by calcination, repeated solutions in water, filtration, &c.

† The calces of metals are something very different from pure, elementary earth, tho probably united with a proportion thereof. These are very apt, *per se*, either with a vehement heat to return to metal again, or else to run into glass; which is not the property of pure virgin earth, devoid of salts. The excellent Mr. *Boyle*, with great probability, shews them to be the magisteries of metals, and has frequently reduced them back from this their disguised state, to that which is natural to them. *See his Discourse upon Fire and Flame.*

with

with cork, and tied down with bladder. Oils, when they depoſite their earth, turn into inflammable or vinous ſpirits: and there is no chemical principle, fixed and immutable, unleſs it be this virgin, which is diſpoſed to join her ſelf with all kinds of animal, vegetable, and foſſil ſubſtances, for their common ſupport and ſafeguard. There are two grand enemies to all theſe bodies; fire and water; neither of which hath any natural power to alter or deſtroy the chemical earth; whence this is an excellent common preſerver of them all. Thus the ſolids of our bodies being merely compoſed of ſuch earth, they can never be deſtroy'd by the natural agents which are continually at work thereon; and being alſo diſtributed among the fluids, or ſoft parts of animals and vegetables, it greatly conduces to their preſervation, and continuance in their natural ſtate: but unleſs they were thus mixed with, and detained by the elementary earth, they would all preſently exhale into the air in the form of effluvia. And poſſibly all the bodies in the world, if perfectly deprived of their earth, would be turned into mere ſpirits.

The chemical uſes of our elementary earth, are very conſiderable. *Its uſes in chemiſtry.* We have already obſerved, that it is this matter of which teſts, cupels, and veſſels capable of enduring the moſt violent fire, are made, for the ſervice of alchemiſts or ſuch as purify metals. And indeed it is the baſis of all manner of chemical veſſels, unleſs we are to except thoſe that are made of metals; for all thoſe of particular vulgar earths and glaſs, have a large proportion of it in their compoſition; whence their durability and fixedneſs in the fire.

Our elementary earth is alſo of great ſervice in chemiſtry, on account of the property it has to render all fixed ſalts volatile; which could not be done without its aſſiſtance, and is no inconſiderable ſecret in the art. Thus if ſea-ſalt, for inſtance, were, in a coated retort, expoſed to a violent heat, the ſalt would thereby be made to flow indeed, but not to loſe of its original weight; the veſſel would ſooner be melted down, and if made of earth, it would ſooner be corroded and penetrated by the ſalt, than the ſalt would riſe in diſtillation; but mix three or four times its own quantity of elementary earth therewith, and this will prevent its running, and cauſe it all readily to riſe in an acid ſpirit by diſtillation. And after the ſame manner may the ſalt of tartar, and other fixed ſalts, be rendered totally volatile; the earth made uſe of in the operation being incapable of flowing or vitrifying with that degree of heat which ſerves to raiſe them. Whence it appears, that elementary earth is the grand inſtrument not only of fixation, but likewiſe of volatilization.

A farther uſe of this earth is made in diſtillations; when oily or unctuous ſubjects are to be treated in that way, ſuch as wax, honey, *&c.* which cannot conveniently be diſtilled alone, as being very apt to ſwell, bubble up, and boil over the neck of the retort, and break the veſſels by the exploſive matter they contain; whence great damage has ſome-

times

times been ſuſtained. But by the mixture of our earth, or even, in its ſtead, calcined harts-horn, the powder of bricks, or the like, will effectually prevent any ſuch exploſions during the operation; and by breaking the coheſion of the parts of the ſubject, and keeping them aſunder, cauſe the diſtillation to proceed regularly, and with all deſirable ſafety. And by this means a body naturally unfit for diſtillation, may be rendered a proper ſubject for it. The want of knowledge in this particular, might prove of fatal conſequence. In order to prepare the phoſphorus of urine, the ſubject matter ſhould firſt be reduced, by boiling, to the conſiſtence of honey; but then it can never be diſtilled, on account of the bubbles which would continually riſe therein, unleſs three parts of earth are firſt added thereto; after which the operation may be ſecurely carried on to advantage. And the ſame is to be underſtood of the diſtillation of human blood.

Elementary earth, likewiſe, admirably ſerves for the purification of ſalts and ſpirits from the oils wherewith they are commonly clogged and rendered impure; for it is a great attractive of oil. Having once boiled ſome bones in *Papin*'s digeſtor, till they were freed from their oil, and rendered ſo ſoft and ſpongy, that I could cut them with a knife, like a turnip; they preſently grew hard again upon plunging them into oil. Thus any bone-aſhes, calcined to perfect whiteneſs, and reduced to powder, being ſteeped in oil, will immediately become conſiſtent and hard. This property which our earth has of attracting oil ſo ſtrongly, fits it for ſeveral chemical experiments. Thus, for inſtance, when the volatile ſalt of harts-horn is turned yellow by the quantity of oil contained therein, we have nothing to do but to mix it with three or four times its own weight of virgin-earth, and re-ſublime it; which will make it appear perfectly white and fine: the addition employ'd, keeping its oil behind, which before tinged the ſalt yellow. And 'tis no trifling ſecret in chemiſtry, to be able thus to purify and ſeparate ſalts from oils; which is always done to greater perfection, the larger the quantity of the earth employed about it *.

There

* The doctrine of elementary earth here delivered, appears greatly to countenance Sir *Iſaac Newton*'s notion of the original formation of matter; by ſhewing that an unalterable ſolid ſubſtance has a real exiſtence in nature. That great philoſopher is pleaſed to tell us, it ſeems to him, ' That God in the beginning ' formed matter into ſolid, maſſy, hard, impenetrable, moveable particles, of ſuch ſizes ' and figures, and with ſuch other properties, ' and in ſuch proportion to ſpace, as moſt ' conduced to the end for which he formed ' them; and that theſe primitive particles, being ſolids, are incomparably harder than any ' other bodies compounded of them; even ſo ' hard as never to wear, or break in pieces; ' no ordinary power being able to divide ' what God himſelf made one in the firſt creation. While theſe particles, *ſays he*, continue ' entire, they may compoſe bodies of one and ' the ſame nature and texture in all ages: ' but ſhould they wear away or break in ' pieces, the nature of things depending on ' them would be changed. Water and earth ' compoſed of old, worn-out particles, and fragments of particles, would not be of the ſame ' nature and texture now with water and earth, ' compoſed of entire particles in the beginning. ' And therefore, that nature may be laſting, ' the changes of corporeal things are to be ' placed

There is alſo another kind of earth, beſides the virgin, uſed in the practice of chemiſtry, *viz.* a particular ſort of clay, or potters-earth, whereof chemical veſſels are formed: but of this we ſhall here take no farther notice, having already conſidered it under earth in general; and ſhall do it again when we come to treat of chemical veſſels.

'placed only in the various ſeparations, and new 'aſſociations and motions of theſe permanent 'particles; compound bodies being apt to 'break, not in the midſt of ſolid particles, 'but where theſe particles are laid together, 'and only touch in a few points.' *Newton*'s *Optics*, *p.* 375, 376.

# *Of* MENSTRUUMS.

THERE is nothing in all the art we are treating of, more curious, uſeful, and neceſſary to be known, than the doctrine of *menſtruums*; tho the ſubject has hitherto been but imperfectly cultivated: ſo that, indeed, no part of chemiſtry lies more in confuſion than this. It ſhall, therefore, be our preſent endeavour to deliver it with all the fullneſs and accuracy we are able.

*Menſtruums, what.* *A menſtruum is any ſenſible body, which, being applied to another, intimately mixes therewith, ſo as to diſſolve it, at the ſame time that it is it ſelf diſſolved; the minute parts of both thence coming to be exquiſitely blended, and together compoſing a new whole.*

*The manner of of their action.* Menſtruums, therefore, are ſolvents with regard to the bodies they diſſolve; tho in the ſolution themſelves are alſo diſſolved: for all the parts of the ſolvent are interpoſed between all thoſe of the ſolvend, and *vice verſâ*; the action being reciprocal. Hence a menſtruum, tho it may be ſaid to act mechanically, does not act after the manner of ſaws, wedges, or the like mechanical inſtruments; becauſe theſe do not become one with the bodies they divide. A knife, when it ſeparates the parts of a bisket, does not operate as a menſtruum thereon; becauſe it unites not with it: but water boiled up with the ſame, becoming one body therewith, proves a proper ſolvent or menſtruum for it. Every menſtruum then, muſt it ſelf be diſſolved in the act of ſolution; ſo that both ſolvent and ſolvend reſolve at the ſame time: for ſolvents can act only by interpoſing every part of themſelves, between every part of the bodies they diſſolve. And hence it is evident, that all menſtruums muſt needs be fluid at the time of their action; for fluids only are thoſe bodies which conſiſt of ſmall, inviſible, moveable parts, that give way to the leaſt force impreſſed upon them: and ſuch muſt neceſſarily be the particles of menſtruums, which ſo eaſily inſinuate into the pores of bodies, and perfectly diſſolve them. And thus ſilver may become the menſtruum of gold; for if an ounce of the former be fuſed with a grain of the latter, all the parts of the ſilver will be united intimately with thoſe of the gold; and with it compoſe one maſs. Hence we learn, that ſolid menſtruums ought by all means to be diſſolved at the time they are deſigned to act; that the particles of the ſolvent may come in contact with thoſe of the ſolvend. Thus when *Aqua regia* perfectly diſſolves gold, all the particles of the menſtruum come to touch all the particles of the metal.

*Their two kinds of action.* It is eaſy to perceive, from what is here laid down, that there are two kinds of action in menſtruums, or that they may either act by the common properties of fluids, as their gravity, fluidity, *&c.* or by a peculiar and unknown force reſiding in each particle thereof.

The term *menstruum* seems to have had its rise from hence: *Lully*, and some other antient chemists, observing the most kindly solutions to be made, by digestion, with a heat no greater than that of the human body, in about forty days, they termed this space of time a philosophical month: and hereupon called the solvent employ'd the *menstruum*; intimating the body that performed the dissolution by a menstrual digestion. This term, indeed, was at first appropriated to the solvent for the *philosophers stone*; but it afterwards became a general appellation for all solvents. *Origin of the name.*

Now, tho there are no bodies to be found that can perform the office of a menstruum in a solid and dry form; whence that common saying in chemistry, *salts act not before they are dissolved*; yet custom has made it familiar to call such dry and solid bodies menstruums too, as have the power of dissolving after they are made fluid. We shall therefore divide them all into two classes, the dry or solid, and the moist or fluid. *Two different kinds of menstruums, solid, and fluid.*

1. To the tribe of solid or dry *menstruums*, we, in the first place, refer all metals, which are *menstruums* to one another; and perform that office more exquisitely than any other solvents hitherto discovered. Thus, for instance, if a hundred grains of silver were melted with one grain of gold, every single grain of the mass they compose will contain the hundredth part of a grain of pure gold. And unless this was the case, there could be no such thing as the art of *assaying*; which entirely depends upon the supposition, that whenever two metals are fused together, they will be intimately and uniformly mixed: for if such mixed metal were brought to a *say master* to determine the quantity of gold in it, he would first melt the whole lump, and after it was cold, cut off a grain weight thereof; which, cupelled with lead, or put into *Aqua fortis* or *Aqua regia*, would yield its proportion of silver or gold; by the weight whereof he would determine the richness of the whole lump. And this shews us, that one metal may indefinitely divide another by fusion; for if in the present case, the quantity of the silver were continually increased, whilst that of the gold remained the same, who can set any bounds to its division? And by the same means all other metals are capable of being infinitely divided. Thus quick-silver, which unites with all metals, except iron, will divide them to a surprizing degree of subtilty: so that if a grain of gold were fused with any assignable quantity thereof, it would be uniformly diffused thro' the whole, and blended with the minutest parts thereof. Whence we may learn, that metals are the best *menstruums* for metals; and that nothing can open one metal more than another metal. *Solid menstruums are either metals,*

2. *Sulphur* also is a menstruum with regard to metals: thus quick-silver, for instance, poured upon it whilst in fusion over the fire, will be drank up thereby, with a hissing noise; and if they are well ground together in equal quantities, without heat, they will turn to a black powder, or mass, called *Æthiops mineral*; which being sublimed in a *Sulphur*,

 glass-

glaſs-veſſel, and a naked fire, becomes *cinnabar*. In theſe three operations, the mercury is divided by the interpoſition of the parts of the ſulphur, tho not ſo ſubtily as when it amalgamates with metals.

And if ſulphur be calcined with any of the ſix other metals, they will ſcarce be perfectly deſtroyed thereby; but their metalline parts remain mixed and united with thoſe of the mineral. And ſuch a body as this is calcined lead, or iron treated after the manner of Dr. *Willis*; for the drops which fall from red-hot iron, when ſulphur is thrown upon it, participate as well of the metal as the ſulphur.

*Semi-metals,* 3. All minerals alſo of a metalline nature are ſolid menſtruums, and particularly *antimony*; which diſſolves metals with as much eaſe as fire thaws ice. But there is no method yet known of recovering the metals with which it has once been fuſed; all of them, except gold, being loſt in cupellation therewith: which gives ſuſpicion that it deſtroys their metalline nature. This is certain, that nothing is better ſuited to change their nature than antimony; whence I cannot but ſuſpect the *adept* made uſe of it, as a menſtruum, in the preparation of their *ſtone*. Nor do I believe there is a better way to obtain that ſecret; at leaſt, were I to go in queſt of it, I ſhould willingly begin my inquiries with this property of antimony.

*Or ſalts,* 4. Laſtly, *Salts* are ſolid menſtruums; for all the known ones, whether acid, alkaline, neutral, fixed, volatile or compound, naturally aſſume a ſolid form, when they can be obtained without any mixture of oil or water. Even vinegar may be ſeparated from all the oil that adheres to it, and be converted into a dry and ſolid ſalt. Volatile acid ſalts alſo may be fixed, and made to appear in their own ſolid form, by mixing them with their oppoſites. For example, ſhould an ounce of *Glauber*'s very volatile ſpirit of nitre be mixed with ſix ounces of oil of tartar, and two of water, and then diſtilled in a retort, till the remainder became dry; all that appears in the receiver will prove inſipid phlegm, and two ounces of dry ſalt remain at the bottom of the retort, containing all the acid of the nitre. Whence it appears, that the moſt volatile acids may be fixed and rendered ſolid, if all their oil and water be driven from them. This, indeed, is exceeding hard to be done in vinegar, becauſe of the large quantity of oil it contains; and hence the difficulty in regenerating *Sennertus*'s ſalt of tartar, ſo as to prevent its running.

We look upon all ſalts, therefore, as dry menſtruums, tho they appear perfectly inactive, till by the fire, or ſome liquor, they are brought to flow; and then they will exert their force upon almoſt all the known bodies. When ſalt of tartar is calcined to a great degree of ſharpneſs, it will not corrode any very dry ſubſtance; but if it be applied to a man's skin, the exhalations of the body will preſently diſſolve it, and cauſe it to act as a cauſtic.

*Cementation, what.* When ſalts are attenuated by the vehemence of the fire, and rendered fluid, they enter wonderfully into all kinds of metals; but if uſed in

in a dry form to diſſolve them, they are then termed *cements*. *Cement*, in propriety of language, ſignifies that mixture of water, ſand, and lime, made uſe of to join and faſten together the parts of buildings; but in chemiſtry we mean by it a *dry powder*, to be ſtrewed between layers of metalline plates, in order to their calcination or diſſolution. This powder is generally compoſed either of ſal-gem, ſal-ammoniac, or nitre and brick-duſt, mixed together: and thus it has the power of deſtroying almoſt all kinds of metals, when it is laid between their plates, and kept in fuſion therewith; nay, ſometimes it even carries them off with it ſelf. But ſalts act not by way of *cement* till they are brought to flow; for, till they fume, they produce no effect upon the metal: but to emit fumes, is to be in a fluor; and thus all *cements*, moiſtened with water, or with urine, act upon metals; for they are thereby made fluid, and whilſt they diſſolve other bodies, are themſelves diſſolved thereby.

No dry menſtruum can poſſibly act, unleſs their parts be in motion; for they muſt neceſſarily be impelled againſt the bodies they are to diſſolve: and this *impetus* they may acquire by trituration, humectation, and heat. Trituration has a wonderful force to diſſolve ſome bodies, and will render them as fluid as if they were fuſed by the fire. Thus if you grind the powder of myrrh, and ſalt of tartar together, they will diſſolve each other. By rubbing new and bright filings of iron in a mortar, with double their weight of clean ſulphur, the iron will be diſſolved, ſo as by diluting it with water to afford the *vitriolum Martis*. Gold long ground in a mortar, with ſalt of tartar, will yield a kind of tincture; and rubbed with mercury, in a mortar of glaſs, it entirely diſſolves into a purple liquor, and becomes a moſt powerful medicine. Dr. *Langelotte* has wrote a curious treatiſe of *the great effects of trituration in chemiſtry*; and deſcribes a peculiar way he employed to grind gold, whereby he could render it as fluid as the fire does, and make an *aurum potabile* by the bare motion of a mill *. And thus dry and ſolid metals might, by ſtrong trituration, be brought to afford a variety of menſtruums.

*Whence dry menſtruums act, viz.*

*By trituration.*

*Humectation* is another means of giving force to menſtruums; and this may either be natural or artificial, and proceed from water or oil.

*Humectation.*

* We find in the *Philoſophical Tranſactions*, Nº 87, an account of a letter written by this Dr. *Joel Langelotte*, chief phyſician to the duke of *Holſtein*, wherein mention is made of his way of grinding gold, and two engines, or philoſophical mills, are there deſcribed for the purpoſe; with one of which, in the ſpace of fourteen natural days, he reduced leaf-gold to a dusky powder; and putting it into a ſhallow retort, placed in a ſand heat, he thence obtained, by gradually increaſing the fire, and giving a ſtrong one at laſt, a few very red drops; which, digeſted *per ſe*, or with tartarized ſpirit of wine, afforded a pure and genuine *Aurum potabile*. The ſucceſs of this operation, the Doctor attributes in great meaſure to the ſalt of the air, which in grinding plentifully mixes and unites it ſelf with the gold: but this particular he then deſigned to give farther proof of in his account of ſome uncommon experiments made in the laboratory at *Gottorp*. By means of trituration he likewiſe declares he obtained the genuine mercury of antimony.

'Tis obſerved by *M. Homberg*, that all metals ground with water give an *aurum potabile*. There are many ſalts which will diſſolve nothing at all till they have been moiſtened with water; and tin cannot be mixed with lead, but by means of it. The air continually abounds with water, by which it runs the ſalts that are expoſed to it; and the humectations obtained from hence are greatly eſteemed. In this caſe, *Geber*, *Lully*, and others of the reputed adept, would ſay the ſpirit of the air inſinuates into and diſſolves the body. Oil alſo, by humectation, will promote the diſſolution of bodies; as is evident in ſulphur, which it converts into a balſam.

*And heat.* Of that great and general force given to menſtruums, or all natural bodies, by *fire*, we have ſufficiently treated already, in the particular chapter of that grand chemical inſtrument.

*Liquid or fluid menſtruums, are either,* There are two kinds of liquid menſtruums; ſome being general, as diſſolving all bodies indifferently; others particular, as having a limited force, ſo that they work upon ſome certain bodies only. Of the latter there are eight *Claſſes*.

*Aqueous,* 1. *Aqueous menſtruums* make the firſt; wherein water appears to be ſo predominant, that they ſeem compoſed of nothing elſe, whereto their ſolutive power can be aſcribed. Under this claſs we rank, (1.) *Water* of all kinds, as river-water, ſpring-water, rain-water, diſtilled water, *&c.* And (2.) *Dew*, as 'tis commonly called; which, tho it appears to conſiſt of nothing but water, is really a mixture of a number of bodies, as oils, ſalts, lixiviums, *&c.* for theſe by heat are raiſed in vapour as well as water, and floating in the air, fall down together with it in the form of dew.

*Oleaginous,* 2. *Oleaginous menſtruums* come in the ſecond claſs. Pure oils conſiſt of two parts, a fiery one and a viſcous, which wraps up the fire. But many foreign bodies are apt to mix and entangle themſelves with oils; whence their power of diſſolving differs according to the different natures of the bodies blended with them. Under this claſs are contained, (1.) *Native oils*, or *balſams*, as found in animals and vegetables; or as they exſude out of the earth. Vegetable oils have always ſomething groſs, earthy, and aqueous, in their compoſition; and by reaſon of the acid they contain, are menſtruums very different from thoſe oils which have nothing of acidity in them. Turpentine ſpread upon copper, will corrode it, ſo as to turn it green; but when deprived, by diſtillation, of the acid parts it contains, 'twill not at all prey upon that metal. Some chemiſts pretend, that pure oils will diſſolve metals; but I find, by repeated experiments, that if they be perfectly freed from their water and ſalt, they will not touch them. And 'tis from this acid part of theirs, that when rubbed upon iron utenſils, to guard them from ruſt, they, on the contrary, prove inſtrumental in bringing it on, unleſs they be firſt boiled with ceruſe to imbibe their acidity. (2.) *Expreſſed oils*, which differ from the native on account of the manner wherein they are obtained. The moſt oily parts of vegetables are made choice of for

for this purpose; which being suffered to dry, so that as much of their water and acid may fly off as can possibly escape, the remainder is well bruised and committed to a strong press, that forces out the oil; which by this means seems to be more intimately united with the remaining aqueous and saline parts; whence these become more impure than native oils, perform their solutions accordingly, and easily grow rancid. (3.) *Distilled oils*, which, if obtained by means of water, are called *essential*; and if without it, whether by *ascent* or *descent*, *empyreumatical*. *Essential oils* always contain a copious acid spirit, that is very penetrating; by means whereof they effect strange solutions. They also have some aromatic parts, upon which their solutive power in good measure depends. By shaking these oils for a long time with warm water, often poured on a-fresh, they part with their acid and aromatic spirit; whence they become soft and unfit for certain solutions. The empyreumatical oils are possessed of an exceeding sharp salt, which gives them their faculty of dissolving. (4) And lastly, under this class are contained *oils exsuding from the earth*, which contain a large proportion of acid salt; from whence they obtain their power of dissolving bodies.

3. *Alcaline spirituous menstruums* make the third class; and these are obtained from vegetables and animals. But to give the clearer notion of them, we must here explain what the chemists mean by spirits; for several very different liquors go under that name. Fluids, in distillation, usually appear under two distinct forms, and are either seen in separate drops, adhering, like dew, to the sides of the receiver; in which case we term them aqueous fluids; or else they trickle down in certain unctuous veins or rivulets; and then we term them either oils or spirits: oils if they refuse to mix with water, and spirits if they do not. Spirits are either inflammable, and not obtainable without a previous fermentation; or uninflammable, which may be either alkaline or acid. They are these alkaline spirits which constitute this third class of menstruums; and may be defined subtile, volatile liquors, that run in veins down the sides of the vessel in distillation, will not take fire, but mix with water, and contain some alkaline salt. If these spirits be committed to distillation with chalk, they may be resolved into three principles; for there will first ascend a dry, white, volatile salt; next a large proportion of phlegm; and lastly, when the fire is increased, a small portion of a sharp, volatile, fetid oil. These substances, considered in a state of separation, have names assigned them denoting their simplicity; but in a mixed state, we call them spirits; and from their analysis, they appear to be truly saponaceous. These spirits are obtained, (1.) From all the parts of animals, unless we except the milk and chyle, which, perhaps, are not sufficiently ground and attenuated for that purpose. (2.) From all plants after putrefaction. And (3.) From the pungent or aromatic tribe of vegetables, as mustard, horse-radish, scurvy-grass, &c. without putrefaction; for these afford a spirit resolvable into the three

*Alcaline spirituous,*

principles;

principles above-mentioned; and are in no respect distinguishable from the urinous spirits of animals.

*Acid spirituous,* 4. *Acid spirituous menstruums* come in the third class. Acid spirits are subtile, volatile liquors, which run in veins by distillation, will not burn in the fire, but unite with water, and have a very sour and pungent taste. Such are the spirit of verdigrease, or *Zwelfer*'s alcahest, spirit of nitre, oil of vitriol, spirit of salt, spirit of alum, *&c.* These spirits consist of a large portion of water, and a little acid salt, as appears upon their analysis: for if oil of vitriol be distilled from double its weight of chalk, it will yield almost its own full quantity of phlegm; which does not proceed from the chalk employed; for this will scarce afford the least water by the most violent fire: whence oil of vitriol appears to contain but a very small portion of acid. These spirits are obtained, (1.) From *vegetables*, either distilled with water, or after fermentation; for all plants distilled with water, afford a truly acid liquor. And the first running of the water obtained by distillation from balsams, is an acid spirit. (2.) From *fossils*; for all fossil salts, as sal-gem, nitre, vitriol and alum, as well as sulphur, *&c.* borax only excepted, yield acid spirits by distillation. But from animal substances, no acid spirits are obtainable; tho 'tis possible to extract them from those imperfect animal juices, chyle and milk. *M. Vieussens* assures us, he could gain an acid spirit from urine; which, indeed, he might: but he mistakes in taking that for an animal acid, which proceeds barely from the sea-salt received into the body.

*Acid spirits* are commonly divided into *volatile* and *fixed*, tho they all are volatile except oil of vitriol, and spirit of sulphur *per campanam*; and these may easily be rendered so. If oil of vitriol be contained in an urinal, and placed in boiling water, none of the oil will exhale; tho it then appears by the thermometer to be much hotter than the water; whence it is said to be fixed: but if any part of it happens to be raised, it nearly resembles oil of sulphur *per campanam*. All these spirits, except vinegar, seldom contain any oil or earth. Under this class we may likewise rank some native acids, tho they are not spirituous; for instance, verjuice, the juice of citrons, lemmons, *&c.*

*Inflammable,* 5. *Fermented, inflammable spirits* make up the fifth class; that is, liquors exceeding subtile and volatile, which run in rivulets by distillation, mix with water, and are wholly combustible in the fire. All the known vegetables, that do not of themselves turn alkalious, will, when digested, and fermented with water, afford these spirits; tho they never naturally exist in the subjects that afford them; and can never be obtained therefrom without a previous fermentation: nor were they ever, that I know of, extracted from animal or mineral substances. *Helmont*, indeed, relates, that the breath of a man, blown up the *anus*, has taken fire: but if the phænomenon were true, there seems to have been no more in it, than that an inflammable spirit was here produced in the body, from the spirituous liquors received into it. 'Tis also asserted, that the vapours

pour aſcending from a jakes, has in the winter time been fired by the flame of a candle. But ſuch phænomena ſeldom appear: and ſuppoſing them real, they only ſhew that human excrements may, by fermentation or putrefaction, have their oleaginous parts ſo attenuated as to become inflammable.

6. *Fixed alkalies* conſtitute the ſixth claſs; which are gained from the aſhes of plants burnt by a vehement fire, that carries off all their phlegm, ſpirit, and oil. The term *alkali* takes its riſe from the word *kali*, by clapping the *Arabic* particle *al* to it. *Kali* is the name of a plant growing in *Egypt*, about the mouth of the river *Nile*, that proves ſalt upon the tongue; and when burnt in the fire, leaves a copious, fixed ſalt behind in the aſhes. And this is the ſalt which comes to us from *Scanderoon*, under the name of *ſoda*, and is a principal ingredient in glaſs. Theſe ſalts; ſo far as our preſent experience reaches, are obtainable from nothing but vegetables; for that fixed ſalt ſometimes gained from the excrements, blood, or urine of animals, is not an alkaline but a ſea-ſalt. And from foſſils no art could ever yet extract them; for *Tachenius* was miſtaken in ſaying, that ſal-gem, ſea-ſalt, and the like, were partly fixed alkalies. *Fixed alkalies* are diſcoverable by their obſtinately enduring the fire, their corroſive property, their urinous taſte, their faculty of turning ſome ſyrups green, and their conflict with acids. They are very powerful menſtruums, but exert not their force till diſſolved; and therefore will not corrode dry bodies. The ways to make them act are three: firſt, by fuſing them in the fire; at which time they appear like oil, and act with very great violence upon ſome bodies*; ſecondly, by diſſolving them in water; and thirdly, by ſuffering them to run in the air; which is a much better way of purifying theſe ſalts than by diſſolving them with water; for if filtred after they have been permitted to flow in the air, they yield no more fæces in water: but after being diſſolved in water, they depoſite a copious terreſtrial ſediment if expoſed to the air: whence there is no queſtion but they are rendered much more penetrating by being diſſolved in the air. When theſe *fixed alkalies* are fuſed by the fire, we term them *alkaline ſalts*; when diſſolved in water, *lixiviums*; and when run by the air, *oils per deliquium*. *Fixed alkalies.*

7. *Compound ſalts* conſtitute the ſeventh claſs: we define them ſaline bodies, which can neither be called acids nor alkalies. This definition being negative, may ſeem not to expreſs the nature of theſe ſalts; yet it is ſtrictly exact: and whoever bears in mind the general definition of ſalt before laid down, that of acid, and that of alkali, will from thence conceive a clear notion of a compound ſalt, from a negation of the two latter. They are otherwiſe called *ſales enixi*, natural, neutral, hermophroditical, ſaturated, impregnated, mixed, and adiaphorous ſalts; becauſe acid ſalts are called by the chemiſts male, and the alkaline female; *Compound ſalts.*

* As upon ſand, for inſtance, which they thus diſſolve ſo perfectly as to make glaſs of it.

and

and becauſe *Helmont*, *Tachenius*, &c. thought them compoſed of acids and alkalies, ſo put together as to give the appearance of neither. And what confirmed them in this opinion was, that they yielded acid ſpirits by diſtillation. Whence they inferred, that the acid ſalts were here contained in the alkaline, as ('tis their own compariſon) a knife is contained in its ſheath; which, therefore, being unſheathed by the fire, appear in their own form. To try if there was any truth in this plauſible argument, I committed a pound of nitre to diſtillation, with four times its weight of well-dried potters-clay; and upon the earth remaining in the retort, after the operation was ended, poured warm water, to diſcover whether any ſalt was left behind; but the water gained not the leaſt ſaline taſte thereby; nor did it manifeſt any ſigns of effervescence when ſpirit of nitre was poured thereon. From whence it appears, that ſpirit of nitre is not made by any unſheathing of the acid reſiding in the alkaline cells of the nitre; but by a converſion of the parts that were not acid before, into ſuch as are acid; otherwiſe the whole body of the nitre could never be turned into acid ſpirit. We muſt own, indeed, if oil of tartar *per deliquium*, be poured upon ſpirit of nitre; ſalt-petre, or ſomething very like it, will thereby be regenerated: but we muſt not infer from hence, that this is the way which nature employs to make it.

Theſe *compound ſalts* are ſal-ammoniac, nitre, ſea-ſalt, ſal-gem, borax, and the alums and vitriols of all kinds: for theſe diſſolve in water, flow at fire, as long as they retain their ſaline nature, and are neither acids nor alkalies. Alums are converted into vitriols by a ſtony matter, and chalk into the ſame by an acid one; and if an acid lays hold of a ſemi-metal, it turns it to a vitriol *ſui generis*: which appears to be the reaſon why theſe were called *compound ſalts*. Add to this, that chemiſts found themſelves able, by their art, variouſly to compound and transform ſaline bodies. Thus if you ſet a parcel of ſea-ſalt, or ſal-gem, over a fire, able to exhale its ſuperfluous moiſture, and yet not bring it to fuſion, and afterwards calcine, decrepitate, and grind it with bole, and place it in a vehement fire; 'twill become volatile, tho before it was fixed; moiſt, tho before it was dry; acid, tho before it was neutral; and appear in the form of a liquid ſpirit of ſea-ſalt. Then ſaturate this ſpirit with oil of tartar *per deliquium*, and ſea-ſalt will be regenerated, and appear in its natural form, tho made artificially. Once more, pour this ſpirit of ſalt upon a volatile animal ſalt, and there will be preſented you a ſal-ammoniac, which is neither acid nor alkali, tho made from both. Thus nitre too, which is a fixed adiaphorous ſalt, will, if diſtilled from bole, yield a volatile, acid ſpirit, that being mixed with a volatile alkali, becomes fixed nitre again.

Under this claſs we alſo range *artificial ſalts*, of which there are various kinds; and much better adapted to medicinal and chemical uſes than thoſe afforded by nature; ſuch is the *Terra foliata philoſophorum*, or the regenerated tartar of *Sennertus*; which proves an exquiſite menſtruum for metals,

metals, and opens them ſo as to make them afford admirable tinctures. Such alſo is *Paracelſus's Samech*, or *Tartarus tartarizatus*, by means whereof myrrh, which otherwiſe proves of ſuch difficult ſolution, is readily diſſolved. Indeed theſe compound ſalts are ſo efficacious, both in chemiſtry and medicine, that I make no queſtion but univerſal deobſtruents will, at length, be obtained from them: for no part of chemiſtry lies more open for diſcovery, nor can a chemiſt promiſe himſelf greater glory or gain from any other quarter, than this wide field of menſtruums and remedies.

To this claſs belong alſo the *eſſentificated ſalts*, as they are barbarouſly called, which conſiſt of an alkaline ſalt mixed up, (1.) With an expreſſed oil; as in *Venice ſope*, for inſtance, which is an excellent deobſtruent. (2.) With a diſtilled oil, as in the ſope of *Starkey*, which alſo admirably opens obſtructions. And, (3.) With highly rectified ſpirit of wine, as in the tincture of ſalt of tartar, which proves a powerful menſtruum in extracting the tinctures of amber, myrrh, and gum-lac.

Theſe ſalts may be differently compoſed at pleaſure, from any ſubject, whether of the vegetable, animal, or foſſil kingdom; and by diſſolving them in water, or fuſing them by fire, they will be converted into the moſt effectual menſtruums. Thus, if to any fixed or volatile alkali, you add the acid drawn from a ſaline body, a compound ſalt will be thereby produced; but if ſuch an alkali be united with an oil obtained either from animal or vegetable ſubſtances, 'twill therewith compoſe a ſope, or *eſſentificated ſalt*, retaining the nature or *eſſence* of the oil employed in the compoſition.

Mr. *Boyle* promiſed us a treatiſe *of the chemical deſtruction of ſalts*; and 'tis great pity that he failed to publiſh it; the knowledge of ſalts being of the utmoſt importance. I hope, however, that what has hitherto been ſaid, will convey a clear notion of their natures, differences, and uſes. The antients acknowledged, that without knowing the differences of ſalts, there was no coming at the *cabinet of ſecrets*. The moderns openly declare this to be the only key that can unlock the treaſures of *Hermes*. And *Helmont* bids us, if we connot attain to the *alkaheſt*, learn to render fixed ſalts volatile; whereby a ſubſtitute may be obtained for that univerſal ſolvent.

8. *Various compoſitions of the ſeven preceding claſſes*, make the eighth and laſt claſs of particular fluid ſolvents; tho it may admit of a doubt whether more than three of them can at once be mixed to equal advantage. Thus if *Starkey's* ſope, which is made of the æthereal oil of turpentine, and purified ſalt of tartar, be exquiſitely united with highly rectified ſpirit of wine, the active principles of the compoſition, namely, the ſalt, oil, and ſpirit, retain their full force; but if more ingredients were added, 'tis a chance that the virtues of ſome of them would be prejudiced thereby. However, the manners of varying and differently compounding of them are endleſs. And here I cannot but wiſh that menſtruums of all kinds were ſeverally applied to the human *calculus*; *Or other compoſitions of the former.*

for I think there is ſome reaſon to hope that its ſolvent may be diſcovered. There are bodies in nature that act after a peculiar manner in conjunction with others: thus that ſubtile alkali, ſpirit of urine, being united with rectified ſpirit of wine, makes the *offa alba* of *Helmont*; a menſtruum ſo powerful as to diſſolve various bodies, which without it were inſoluble.

*The nature of the action of* menſtruums.

1. From what we have here laid down of menſtruums, it appears, that none of them can act, unleſs firſt put into motion; and that they produce not their effects by any *irradiation*, as *Helmont* would have it. A load-ſtone that is abſolutely and in all reſpects at reſt, could never ſurely act upon iron; but muſt, by a near approach thereto, have its parts put into motion: and if this be the caſe in a magnet, with much more reaſon may the like be allowed of menſtruums.

2. Some menſtruums have a principle of motion within themſelves, whereby they are determined to run into the embraces of particular bodies, and diſſolve them; the motion of the ſolvent and ſolvend being reciprocal, according to Sir *Iſaac Newton*'s doctrine of attraction. And indeed it does appear from phyſical obſervations and experiments, that the Creator has not only eſtabliſhed mechanical principles, whereby bodies in general are moved; but alſo given a particular ſtructure to ſome, which remaining entire, is the cauſe of operations in them, that they would not otherwiſe manifeſt: whence it is that load-ſtones attract iron, and electrics lighter bodies, tho without diſſolving them.

3. Other menſtruums are brought to act by a foreign force impreſſed upon them; which may be deriv'd, (1.) From fire; a higher degree whereof will cauſe a menſtruum to diſſolve a body it would not otherwiſe touch. Thus in a very cold ſeaſon *Aqua fortis* will not work upon ſilver; tho the natural heat of a man's hand might excite it to action. (2.) From water, which quickens the action of menſtruums by diſſolving them. (3.) From the air, which by its heat, motion, vapours or effluvia, may ſtir them up, and add to their force. (4.) From triture, of which there are three kinds; for it may be exerciſed between ſolids and ſolids, between fluids and ſolids, and between fluids and fluids.

4. But it is not every menſtruum, tho ever ſo violently agitated, that will diſſolve every body; particular bodies requiring appropriate menſtruums to ſeparate their parts. *Aqua fortis* will not diſſolve gold, tho made to boil upon it, nor *Aqua regia* ſilver; yet the latter menſtruum eaſily diſſolves gold, and the former ſilver. On the other hand, there are menſtruums which ſcarce manifeſt any motion at all when applied to bodies, yet diſſolve them thoroughly. Menſtruums, therefore, do not act by their acrimony, or the other common properties of bodies; but there muſt be ſome particular and ſecret relation between the ſolvent and the ſolvend, which can only be found out by experiment.

If a quantity of *Engliſh* chalk be put into water, the water will not diſſolve it, even tho made to boil, and tho a ſtrong, fixed alkali be added thereto; but if you drop a little vinegar upon them, the chalk

will preſently begin to fall aſunder, and by pouring on of more, be turned to a watry liquid; laſtly, add a little ſalt of tartar, and it will precipitate the chalk into a calx. Whence we have another clear example, that the vehement motion of a menſtruum will not always enable it to act; and that ſome other principle is required to fit it for action. Every natural body muſt conſiſt of certain minute parts, that are not *phyſically* diviſible into ſmaller; for we are not here concerned with the *mathematical* conception of infinite diviſibility. Thus if a grain of gold were divided into a thouſand equal parts, each part would ſtill be gold; and if every one of thoſe parts could be again divided into a thouſand others, each of theſe would ſtill be gold, and a certain portion of the original grain. And if this diviſion be not ſubtile enough, it might be carried on farther, till at length we arrived at the ſmalleſt phyſical particle, beyond which it could not be divided by any natural power; as having no pore, and being too ſmall to receive the external force of other natural bodies, ſo immenſely larger than it ſelf. This ſmalleſt phyſical particle, I, with *Democritus*, call an atom; not that it is abſolutely incapable of any farther diviſion, but becauſe no external phyſical force can reſolve it. Now this atom muſt have ſome ſurface and ſome figure; ſuppoſing therefore there were two of them alike in all reſpects, and for inſtance cubical; if theſe ſhould be clap'd together, ſo that their two oppoſite faces perfectly touched in all points, without leaving the leaſt pore between them, then 'tis plain that no menſtruum could poſſibly ſeparate them; as being unable to enter where there is no pore: but if theſe two corpuſcles were ſet together, ſo as to leave pores between their junctures, a menſtruum fitly diſpoſed, might ſlide in thereat, and effect a ſeparation. Hence it appears, that menſtruums cannot act, unleſs they be in contact with the bodies they are to diſſolve; nor then neither, if they do not communicate ſome motion to theſe bodies: conſequently the action of ſolution is the removal of the parts of a body from their former coheſions, at the ſame time that they are kept aſunder, and not ſuffered to fall into coheſion again.

The action of menſtruums, therefore, depends firſt upon their inſinuating themſelves between the parts of the bodies they are to diſſolve; and ſecondly, upon the agitation given thereto. But to clear this up the better, we muſt obſerve there are two things requiſite to the coheſion of the parts of bodies; *viz.* that their ſurfaces be in contact, and that the parts be compreſſed towards, or be mutually attractive of each other. Bare contact could never cauſe coheſion; ſome other power, as either compreſſion or attraction, is abſolutely requiſite thereto. Every ſolution, therefore, is the deſtruction of this contact of parts, and the ſuſpenſion of their attractive force, or that power which tended to compreſs them together. But this requires that the ſolvent ſhould inſinuate it ſelf between the parts of the ſolvend, and ſhake them on all ſides till it overcomes the force wherewith they cohere together; and by throwing them off to a certain diſtance from each other, prevent their

contact, and the exertion of their attractive power. And ſuch, in effect, is the action of all menſtruums; nor can bodies be diſſolved by any other means in nature. Hence appears the reaſon why all menſtruums cannot diſſolve all bodies: for if the pores of the body to be diſſolved are ſo ſmall, or ſo diſpoſed, that the menſtruum cannot find entrance thereat; and if they prove ſo wide that the menſtruum paſſes them with too great eaſe, no ſolution can poſſibly follow. And this ſhews us the difficulty, not to ſay impracticability, of finding an univerſal ſolvent, ſuch as the alcaheſt of *Paracelſus* and *Helmont*.

*The conditions requiſite to the action of menſtruums.*

There are four *conditions* required in menſtruums, to render them capable of diſſolving bodies to perfection.

1. The firſt is a due proportion between the ſize of the corpuſcles of the menſtruum, and the pores of the body to be diſſolved thereby: for if the particles of the menſtruum are too ſmall and fine, they may be eaſily tranſmitted thro' the pores of the ſolvend, without producing their effect: and if they were too large, they could not gain admittance between the parts they ſhould ſeparate. And hence it is that ſaline menſtruums reduced to the conſiſtence of oil, will ſcarce act at all upon thoſe bodies they would otherwiſe eagerly fret aſunder. Thus the ſtrongeſt ſpirit of nitre will not touch ſilver, till diluted, or weakned, as they term it, with water; but then thoroughly diſſolves it. The ſame menſtruum will not touch lead before it be let down with twelve times its quantity of water; and oil of vitriol will not corrode iron without a proportion of that weakning liquor. And this lets us ſee the great miſtake of thoſe who think all menſtruums diſſolve the better, the purer they are made, or the higher they are rectified.

2. The ſecond qualification is a determinate figure of their corpuſcles with regard to the pores of the ſolvend: for the pores of different bodies are differently figured; and conſequently require particles of ſuitable figures to enter them. And this may be a reaſon why the ſame menſtruum is not able to diſſolve all kinds of bodies; and why ſome menſtruums, by a change made in the figure of their particles, loſe their power of diſſolving. Thus oil of vitriol, by being digeſted with ſpirit of wine, becomes unfit to diſſolve ſome metals; and ſpirit of nitre, which either alone, or diluted with water, diſſolves all metals except gold; will touch none of them after 'tis dulcified, as they call it, by being digeſted with ſpirit of wine; but, upon ſilver, for inſtance, only gains a red tincture. Thus alſo ſpirit of ſalt, or *Aqua regia*, treated after the ſame manner, will not diſſolve gold, but only grow yellow thereon. And *M. Homberg* has obſerved, that by long continued digeſtion, with fire, the ſtrongeſt acids will loſe their ſolutive virtue: but digeſtion ſeems to be no more than a continual triture, whereby a change is brought upon the parts of the bodies digeſted. On the other hand, we find by Mr. *Boyle*'s writings, that many bodies have, by digeſtion, acquired the faculty of diſſolving, which they had not at all before. Thus the globules of quick-ſilver, being of themſelves

 round,

round, and consequently unfit to corrode bodies, acquire *Spiculæ*, or sharp points, from *Aqua fortis*, if dissolved therein; which render it an unsafe internal medicine. Spirit of salt will not dissolve crude mercury; but, as Mr. *Boyle* observes, if the mercury be first dissolved in spirit of nitre, and afterwards reduced to a calx by the fire, this calx will easily open to the former spirit. From all which, we conclude that a change of figure either in the component parts of the menstruum, or the pores of the solvend, may or may not determine the action of the two to solution.

3. The third qualification requisite to the action of menstruums is solidity and stiffness of parts. The solidity of a body is known by its weight, as we learn from mechanics; and the heavier the matter, the greater, *cæteris paribus*, is its moment or motion; and the stronger its action.

The relative rigidity and solidity of parts between the solvent and the solvend, may exceedingly vary the force of menstruums. The writers of mechanics suppose their instruments, as levers for instance, inflexible, or infinitely stiff; which makes their force and strength the greatest that is possible: and this stiffness depends upon the immutability of their figure. Now a body that is stiff acts very differently from one that is flexible. A knife of brass, or lead, will not cut like one of steel or iron. We have an instance of the great force of the rigidity of particles from what we take in at the mouth; which we call alimental, if it proves so yielding that its nature may be changed into ours, by the force residing in the body; if what we receive this way has only that stiffness as to cause some change in our bodies, at the same time that it self is changed thereby, we call it a medicine; but if it proves so rigid as to be insuperable by the natural actions of the stomach, intestines, *&c.* and alters the body to its destruction, we properly term it a poison. Rigidity will cause an impressed motion to be communicated with the greater force; and its quantity is known in bodies by the greater or less resistance they make to a change of their figure, and their degree of mutability.

This doctrine holds true of menstruums; and therefore, as metals are the stiffest bodies in nature, 'tis impossible to dissolve them kindly by any thing but metals. Tho mercury be dissolved a thousand several times in *Aqua fortis*, it always appears the same upon reduction; and gold will for ever remain unchanged. And hence it is, that no vegetable or animal menstruums can resolve metals into their first principles. Whence those sayings so common in the mouths of chemists, 'Metals are only acted upon by metals; mercurials are dissolved only by mercurials; metals open to nothing but the matter whereof they are composed, *&c.*' And hence it was the elder *Helmont* declared, that 'All menstruums which exert any force upon metals, only exhaust their strength, and weary themselves out thereon, without effecting a thorough dissolution.' The most powerful and rigid menstruums, therefore, are obtained from the fossil kingdom; the next powerful after these from the vegetable;

table; and the weakeſt, ſofteſt, and moſt changeable of all, from the animal kingdom: but ſalt of tartar, the product of a vegetable, is by the elder *Helmont*, ſubſtituted even for the *alcaheſt*. *M. Homberg*, by a courſe of digeſtions, continued for ſeveral months, found that menſtruums obtained from foſſils, as oil of vitriol, oil of ſulphur *per campanam*, ſpirit of nitre, ſpirit of alum, *&c.* long remained unaltered; that thoſe from vegetables, as verjuice, vinegar, and the like, were ſoon changed and weakned; but thoſe from animals ſooneſt of all.

4. The fourth and laſt qualification, is a fit diſpoſition of the corpuſcles of the menſtruum, when received into the pores of the ſolvend, to make ſome ſtay there, and not immediately paſs thro' them, but act every way upon the body, as they move toward the external ſurface thereof. Unleſs this were the caſe, no ſolution could ever be made: for if the particles of a menſtruum, when received into the pores of the ſolvend, were not to move forwards, they would conſtitute one body therewith; whence no ſeparation of parts could poſſibly enſue. There is, therefore, requiſite to this action, ſome cauſe able to drive on the particles of the menſtruum, after they are admitted into the pores of the ſolvend; tho not with a free and eaſy motion. This impulſe may proceed from the air, triture, *&c.* but perhaps principally from the never-ceaſing action of fire; for all other bodies, if ſingly conſidered, or as having a ſeparate and independent exiſtence, muſt remain at reſt for want of an attractive power to excite them. Thus even water would be a moveleſs body, were not the fire contained therein to agitate its parts, and keep them in a fluor; for deprive it of this, and it will immediately be converted into ſolid ice. Now, fire exerts but little action upon uniform and perfectly ſmooth bodies; as gold, from the great homogeneity of its parts, ſcarce ſuffers any alteration by it; whilſt wood, for the contrary reaſon, has a great change made in its parts thereby. Whence we may infer, that the corpuſcles of a menſtruum ought ſo to be ſtruck into the pores of the body to be diſſolved, that ſome diſſimilitude, difference, or heterogeneity of parts, may thence ariſe; as would happen if the particles of the menſtruum entered the pores of the body with one end, whilſt the other ſtuck out above its ſurface: in which caſe, the fire, by ſtriking upon all the extant parts, would wedge them in farther, and thereby effect the diſſolution. But if the whole particle ſhould at once enter, ſo as to conſtitute one homogeneous body with the ſolvend, no diſſolution would thereby be procured. And this gives us the reaſon why heat, tho in general it promotes diſſolution in bodies, by cauſing the ambient fluids to impinge with the greater force upon the extant parts of the menſtruum, may, in ſome caſes, prove an impediment thereto; by driving the corpuſcles of the menſtruum ſo far into the pores of the ſolvend as to leave no part of them extant, or expoſed to the force or agitation which ſhould bring about the ſolution. Thus the flowers of zink, when boiled in vinegar, remain untouched therein, like ſo much ſand; yet will preſently diſſolve, if the vinegar be

poured

poured on cold: the ſame alſo happens in a mixture of iron and tin; whence, poſſibly, zink is a compoſition of thoſe two metals. On the other hand, there are ſome ſolutions that require the aſſiſtance of heat; for inſtance, ſpirit of nitre will not diſſolve mercury without it. But it is not ſtrictly true, we ſee, that all ſolutions will be the better performed, the greater is the heat employed to make them. Diſſolutions are carried on in the greateſt perfection, when the corpuſcles of a menſtruum, received into the pores of the ſolvend, are reſiſted by the way; yet continue moving, tho ſlowly, forwards. Upon the whole, it appears, that every menſtruum requires a certain ſize, gravity, and motion of its parts, to determine it to action; after being applied to the body whereon it is deſigned to act. This application is made by means of gravity, without which one body could never be applied to another; but this gravity varies with the quantity of the atmoſphere concerned: whence ſalts cannot be made to act as ſolvents in the exhauſted receiver; and all things loſe their taſte upon the tops of very high mountains.

*General concluſion from the preceding doctrine.*

From what we have hitherto laid down of menſtruums, we may draw this general concluſion; that as the primary elements of bodies are never diſſolved, all the chemical ſolutions, made by means of menſtruums, reach no farther than to ſeparate one primary element from another; the particles of the firſt compoſition being abſolutely ſolid, with regard to chemical operations; ſince their pores, if they have any, are impervious to the fineſt particles of our ſolvents; on which account, they may, with regard thereto, be well enough ſuppoſed to have none: for there muſt of neceſſity be a certain proportion between the particles of the ſolvent, and the pores of the ſolvend. I cannot recollect any experiment whereby either fire or air appeared to be changed; and ſome will queſtion whether the particles of water are capable of alteration, if, by any means, it could be obtained perfectly pure. It ſhould ſeem to me, that God originally divided matter into numberleſs particles infinitely ſmall, and uncapable of any farther alteration or change by the eſtabliſhed powers of nature; and that the reſolution of bodies into theſe original corpuſcles, is the utmoſt effect of chemiſtry; beyond which it cannot go, in the buſineſs of ſolutions *. But theſe elementary corpuſcles only ſeem incapable of farther change or ſeparation of parts, becauſe they are perfectly ſolid, or at leaſt becauſe their pores are too ſmall to be entered by any bodies in nature. Thus pure oil of vitriol will not touch iron, nor ſpirit of nitre ſilver, till diluted with water; whence it evidently appears, that the ſaline corpuſcles of the

* Sir *Iſaac Newton* ſeems to be of opinion, that even the ſmalleſt cluſter, or moſt ſimple compoſition of theſe primary particles, if not the primary particles themſelves, may be diſſolved by means of fermentation; and that if the original corpuſcles, or primary particles of gold, for inſtance, could once be brought to ferment, whereby they would be broke into ſtill finer particles, that metal might be changed into any other body in nature. *Vide apud Harris Lexicon Technic. in Initio.*

oil,

oil, or ſpirit, were at firſt too groſs to get in at the pores of the metal; which they were enabled to enter, when diſſolved and broke into finer *ſpiculæ* by the water. That the menſtruum, in this caſe, really enters the pores of the metal, appears from hence, that if a dram of ſilver be put into an ounce of ſtrong ſpirit of nitre, diluted with a due proportion of water, the diſſolution will immediately be effected; after which, if the water be evaporated or drawn off, it will prove inſipid upon the tongue, and leave all the acid behind, united with the ſilver, into a maſs of thin, ſeparable plates, which are ſtrongly corroſive. Whence it is manifeſt, that the acid of the nitre, which, by the aſſiſtance of the water, diſſolved the metal, entered, and ſo ſtrongly fixed it ſelf in its pores, as not to quit them with the water that was afterwards drawn off. And this remaining maſs, being dried and fuſed, becomes the *Lapis infernalis*.

The corpuſcles of every menſtruum are, therefore, to be conſidered as a parcel of ſmall wedges, of a determinate figure, ſize, ſtiffneſs and gravity, driven by the preſſure of the air, or the action of fire, with a certain force, into the pores of bodies; which, if they paſs not too freely; they dilate, raiſe, disjoin, ſhake aſunder, and throw off their parts; break their coheſions, and prevent their returning into them again. And thus we have mechanically explained the actions of menſtruums; but there are other effects of them not yet reduced under this obvious notion: the principles of their motion remaining utterly unknown to us, tho we are acquainted with the laws thereof.

Corollaries *from the actions and* conditions *of* menſtruums.

It will here be convenient, by way of corollary, from the doctrine hitherto delivered of menſtruums, to give the ſeveral particulars it leads to.

1. And firſt we may ſee that motion alone is not the cauſe of the diſſolving power in menſtruums.

2. That we cannot judge of their force *à priori*, or from the manner wherein they affect our ſenſes, or the organs of taſte, touch, *&c.* for corroſiveneſs to the tongue, or other parts, is no proof of a ſolutive power with regard to other bodies. Experiment alone can inform us in this point: 'tis this which ſhews us that *Aqua fortis*, tho it eats into the fleſh, will not touch gold, yet readily diſſolves the other ſix metals; that oil of tartar *per deliquium*, tho it corrodes many parts of the human body, is a preſerver of the teeth, if uſed with caution; that *Aqua fortis*, tho fiery, and vehemently corroding upon the palate, will not touch wax, tho it preſently frets metals aſunder; that oil, tho almoſt inſipid, ſcentleſs, and ſcarce capable of giving pain, even when applied to the eyes, will make a thorough ſolution of ſulphur, which neither *Aqua fortis*, *Aqua regia*, ſpirit of ſalt, oil of vitriol, nor Mr. *Boyle's menſtruum peracutum* would effect; that air and water, tho perfectly taſteleſs, fret iron into ruſt, copper into verdigreaſe, and diſſolve ſalts, which the higheſt ſpirit of wine, that burns the mouth, will not touch; and laſtly, that ſo innocent and harmleſs a ſpirit may, by bare diſtillation, be

gained

gained from common bread, as to be drank with ſafety, or poured into wounds without cauſing pain; which is yet ſo powerful and wonderful a menſtruum, that it will diſſolve ſtones, as Mr. *Boyle* diſcovered.

3. That the hardneſs or ſtrength of a body neither retards nor promotes its diſſolution. Pure gold, that has been refined with antimony, is ſo ſoft, that it cannot be worked alone; and ſteel, artificially tempered, ſo hard, that it will cut ſuch gold in pieces; yet any common acid will diſſolve the ſteel, but not touch gold: and by means of a ſlender thread, drenched in ſuch an acid, may the ſtrongeſt iron-bars be dextrouſly cut or ſawed aſunder. We cannot, therefore, ſay of a menſtruum, *it is weak*, and conſequently unable to diſſolve *hard bodies*; nor becauſe a menſtruum diſſolves *hard bodies*, that it muſt, therefore, diſſolve *ſoft ones*; for we experience the contrary every day. *Aqua fortis*, which is capable of fretting metals and ſtones aſunder, exerts no force at all upon wax; wherewith, if any veſſel be lined, you may therein preſerve the moſt volatile and corroſive liquors, as well as in thoſe of glaſs. Vinegar, which may be applied to the ſoft parts of the body without prejudice to them, will yet corrode the bones, the teeth, and coral, into brittle plates or ſhavings; and iron into a crocus. Coral, whoſe tincture the moſt violent menſtruums will not extract, eaſily parts with its fine red colour to new milk, upon being boiled therewith; and thereby becomes white it ſelf. And lead, tho a ſoft body, will not yield to the ſtrongeſt acids; but readily opens to the juice of lemmons, or ſpirit of nitre, diluted with twelve times its quantity of water.

4. That we cannot from particular inſtances of corroſiveneſs in a menſtruum, argue its ſolutive power in the general; for we frequently prefer a reputed weak menſtruum to a ſtronger. Thus, tho oil of almonds be eſteemed ſo feeble or mild, and rectified oil of vitriol ſo powerful and corroſive a ſolvent, yet ſulphur will be entirely taken up by the former, but remain untouched by the latter. And wax, as was before obſerved, will be in no wiſe prejudiced by the moſt violent and corroſive liquors; which gives us leave to hope, that tho the human *calculus* has hitherto reſiſted the force of the ſtrongeſt alkaline and acid menſtruums, yet a proper one may be found to diſſolve it, by injection, without hurting the bladder wherein 'tis lodged: the hardeſt of common ſtones are diſſolvable by liquors that will not touch ſome other bodies; why, therefore, may there not be prepared a menſtruum capable of diſſolving the ſtone in the bladder, without prejudicing the part that contains it? Various ſolutions are performable in veſſels of glaſs, and thoſe of other ſubſtances, if defended on the inſide by wax; without the leaſt damage to the veſſels, or their lining. From all which particulars, it plainly appears, that the powers of menſtruums are only to be determined by experiments. It will, therefore, be convenient to lay down from experiment the laws of their action, and add ſome rules for their direction and management.

Laws *observed in the* action *of* menstruums.

1. *Alkaline menstruums, whether fixed or volatile, dissolve most of the bodies which acids do not meddle with.* Thus every alkali, as spirit of hartshorn, spirit of human blood, *&c.* so thoroughly dissolves sulphur, which no acid will touch, renders it so easy to mix with water, and breaks and grinds its parts to such a degree of fineness, that it is never reducible to sulphur again. And this holds true of every sulphur.

2. *Acid menstruums, whether volatile or fixed, dissolve most bodies that prove insoluble by such as are alkaline.* Thus all metals are dissolvable by acids, and none of them, except copper and iron, by alkalies. Crabs-eyes dissolve readily in acids, but scarce unite with alkalies. Oil of tartar *per deliquium* will not corrode, but gives whiteness to the teeth and bones that are sound, and is therefore used in the preparation of skeletons; but *Aqua fortis*, vinegar, or other acids, would presently dissolve them. And hence it is that acids commonly set the teeth on edge, namely, by beginning to corrode them. 'Tis, therefore, a very ill practice to clean the teeth with acid preparations; which, as they take away the roughness and leave them white, eat away their substance, as we find by the practice of empirics, who venture to make use even of oil of vitriol, and the like, for that purpose.

3. *All acids have not equally the power of dissolving all bodies; but some dissolve one body, and some another.* Thus vinegar excellently dissolves lead, which *Aqua fortis* will not do, unless with water it be let down to the strength of vinegar. *Aqua fortis* dissolves all metals except gold, which it cannot be brought to touch. And the same is to be understood of alkalies.

4. *Every spirituous menstruum has a peculiar subject whereon it operates, which will not open to another.* And the same holds true of all kinds of solvents, according to the various classes under which they are ranged. We shall assign to each its proper objects, in the following rules for the ordering and procuring their solutions.

Rules *for the* management *and* application *of* menstruums. *And first, to prepare solvends for solvents.*

1. 'Tis the office of some menstruums to prepare the way for the operations of others, which would otherwise have no effect upon the bodies they were designed to dissolve. Thus alkaline menstruums digested with sulphur, render it soluble both in spirit of wine and water, wherein it would, without such digestion, be absolutely irresolvable. Mr. *Boyle* relates a great number of experiments, whereby he in vain attempted to extract the tincture of sulphur: but Dr. *Willis* has a method of doing it, by first opening the body of the sulphur with salt of tartar; whereby he obtained a very rich tincture. Thus metalline ores, and antimony, will, when opened with alkaline salts, yield a tincture in spirit of wine. But no sulphureous and bituminous bodies, tho boiled ever so long in aqueous liquors, will be brought to unite therewith, unless they be previously opened by alkalies. None of the metals, besides copper and iron, will yield to alkalies; but if any of them, as silver, for instance, should first be corroded by an acid, then crystallized, and afterwards reduced to a calx, this calx will readily open

open to alkalies, and be exceedingly changed by digeſting with the fixed kind thereof. And upon this foundation it was that *M. Homberg* advanced and experienced a method of reſolving metals into their firſt principles; for alkalies, by abſorbing and drinking in the ſulphureous part of metals, leave their mercury behind. Hence it appears, that acids and alkalies may mutually aſſiſt each other in the reſolution of bodies; which is a great and uſeful ſecret in chemiſtry.

2. *Aqueous menſtruums* take up, (1.) From the *vegetable kingdom*, all manner of ſalts, ſpirits, ſaponaceous and gummy bodies, properly ſo called; but unite not with oils, roſins, balſams, pitch, colophony, and earth. (2.) From the *animal kingdom*, ſalts, ſpirits, ſaponaceous and glutinous ſubſtances, which are only animal juices boiled to that conſiſtence; but not ſuch as are fat, unctuous, or earthy. (3.) From the *foſſil kingdom*, ſalts, and any ſaline, aqueous, or ſaponaceous body (for ſaponaceous earths have been lately diſcovered) and a few of thoſe that are bituminous; but touch not ſuch as are oily, ſulphureous, metalline, ſtony, earthy, and abundance that are bituminous. But all this is to be underſtood of menſtruums purely aqueous; for if other bodies be mixed with them, their action will be altered thereby. Thus, for example, if rain water has any mixture of ſalt, it will corrode iron and copper, which it would not touch if it were pure. *To determine the ſubjects for aqueous menſtruums.*

3. *Sulphureous and oily menſtruums* will not of themſelves act upon any things that are aqueous, ſaline, or earthy; but only on ſuch as are ſulphureous and oily, *viz.* ſulphurs, pitch, bitumens, roſins, and the like. Thus ſulphureous menſtruums diſſolve the ſpirituous and oily parts from vegetables, but leave the others untouched: and oils boiled up with the ſame, extract only their odour, and more ſubtile virtues. Spirit of turpentine, however, thoroughly diſſolves the harder gums, as that of copal and caranna, and thereby makes the moſt beautiful varniſhes; tho theſe gums thus yield to no other oil or ſalt. Theſe menſtruums alſo diſſolve no ſubjects of the animal kingdom, but ſuch as are oily, ſulphureous, or unctuous; and nothing but bitumens, ſulphurs, amber, and jet, from thoſe of the foſſil. Admirable tinctures are extracted from foſſils by oils: thus by digeſting oil of turpentine for a month, upon antimony reduced to an impalpable powder, we gain a fine red tincture, of great virtue in the leproſy and all foulneſſes of the blood; tho it ſcarce differs from the tincture of common ſulphur, obtained with the ſame menſtruum; as being given by the ſulphur of the antimony, which in reality is common ſulphur. And thus oil will draw an abominable tincture from cobalt, by uniting with the arſenic it contains. Whence we may conclude, that all oils which grow red upon bodies, do ſo by diſſolving their ſulphur. *For ſuch as are ſulphureous and oily.*

An experiment related by Mr. *Boyle*, has led ſome people into a belief that oils are ſolvents for copper; tho he only tells us, if pure oil-olive, newly imported from *Italy*, be without farther preparation applied to that metal, it will corrode the ſame, and grow green thereon.

But this ſolutive power proceeds merely from the vegetable ſpirit wherewith that oil conſtantly abounds; for if the ſame oil be thoroughly purified by means of ſalt of tartar, it will have no ſuch effect upon copper. And the ſame ſpirit it is in oil, that makes it appear to corrode iron.

*For the inflammable ſpirituous.* 4. *The moſt pure and inflammable ſpirituous menſtruum,* called *alcohol* or *exquiſitely rectified ſpirit of wine*, unites with, or diſſolves all aqueous, ſaponaceous, unctuous, and reſinous bodies; but meddles not with ſalts, earth, and ſulphur, tho it drinks in the other foſſil oils.

*For the alkaline menſtruums.* 5. *Pure alkalies*, whether volatile or fixed, diſſolve all aqueous, ſaline, and ſaponaceous bodies, as alſo whatever is coagulated by acids; great numbers of which kind of bodies they, therefore, make fluid. They likewiſe act upon ſulphureous and oleaginous bodies, either by decoction, digeſtion, or diſtillation; and bring metals into a fluor, if firſt opened by acids. They moreover exert their force upon all gummy and reſinous ſubjects, and open them ſo as to render them eaſy to mix with water, and capable of yielding their tinctures to ſpirituous menſtruums. Thus pure ſpirit of wine will readily extract a tincture from myrrh, or gum-lac, if they be firſt opened by ſalt of tartar; tho it could hardly be gained by any other means whatſoever. But it muſt here be remarked, that many vegetable ingredients will be ſo ſcorched up by alkalies, made too ſtrong for the purpoſe, as ſcarce to yield any tincture at all. Thus, if in preparing *Elixir proprietatis*, ſtrong oil of tartar be, by it ſelf, poured upon the aloes, myrrh, and ſaffron, they will be burnt up thereby, and not give colour to the medicine; but if that oil be diluted with water, before 'tis put upon the ingredients, the operation will be performed to great advantage. The ſame thing holds true in extracting the tincture of gum-lac; for unleſs the oil of tartar be here diluted, it will burn the gum, as it were, to a coal. And thus fixed alkalies are of admirable uſe in preparing bodies to admit the actions of ſome ſolvents. Boil ſulphur ever ſo long in water, and it will not be diſſolved thereby; but add a little ſalt of tartar to the decoction, and a perfect ſolution will preſently enſue. And by means of this contrivance, water may be made to take up many bodies that it would not otherwiſe touch. Oils will unite with alkalies, and by that means conſtitute ſope; but pure inflammable ſpirit refuſes to meddle with alkalies; yet having the property of diſſolving oil, it alſo may be made to diſſolve the alkali contained therein. 'Twere a very difficult taſk directly to diſſolve ſulphur in pure ſpirit of wine; but 'tis eaſily done, by firſt boiling the ſulphur with an alkaline ſalt, or diſſolving it in oil, and then digeſting it with the ſpirit. By thus making uſe of an intermediate menſtruum it was that a crafty chemiſt impoſed upon the Biſhop of *Cologn*, by ſelling to him a ſham tincture of gold, at an exorbitant price. This artiſt took, ſuppoſe, half an ounce of gold, and two or three ounces of antimony, fuſed them together into a brittle

maſs,

maſs, and afterwards ground them into an impalpable powder, which he, for a long time, digeſted with a fixed alkali, run *per deliquium* in the air, and afterwards with pure ſpirit of wine; and the liquor afforded by the proceſs he called tincture of gold, or *Aurum potabile.* But it was eaſy for thoſe to have diſcovered the cheat, who knew that antimony contains a ſulphur, which being melted with gold, renders it brittle and pulverable; and that all ſulphurs, if diſſolved by alkalies, are thereby rendered ſoluble in pure ſpirit of wine, which will not thence be enabled to take up a metal; ſo that the gold here remained at the bottom, and might eaſily be reduced to its priſtine form; the liquor ſwimming over it being only a bare tincture of ſulphur, which would entirely evaporate by heat.

6. *Acid menſtruums* join themſelves to, and conſequently diſſolve all kinds of aqueous liquors and ardent ſpirits, as may appear from the manner of dulcifying ſpirit of nitre and ſpirit of ſalt; and mix ſo intimately with all oils, as therewith to afford true, artificial ſulphur; as we evidently ſee from that which is produced upon the union of oil of vitriol and oil-olive. They likewiſe fret aſunder, ſplit, crack, diſſolve, or reduce to powder, all kinds of earths, ſtones, gems, *calces*, teſtaceous and petrified bodies, bones, corals, the human *calculus*, tho this be performable only by ſpirit of nitre; and laſtly, all the metals: ſo that there is ſcarce any thing able to withſtand their force. No wonder then that *Hannibal* could break rocks, and gain a paſſage for his army over the *Alps* by means of them. And by means hereof it is, that the magiſteries of pearls, crabs-eyes, *&c.* are made; for after the diſſolution is over, 'tis eaſy to precipitate thoſe ſubſtances out of the menſtruums, by adding a fixed alkali thereto. Acid menſtruums are of three kinds, being either gained from minerals, crude vegetables, or vegetables after they have been fermented. *For the acid.*

1. *Mineral acids* are thoſe of ſea-ſalt, ſal-gem, nitre, ſulphur, alum, vitriol, and antimony, which contains an actual ſulphur, exceedingly like the common; whence proceeds its acid. All theſe acids, except that of ſulphur and antimony, are different from one another; and according to *M. Homberg*, all ſalts do not participate of the ſame acid. Spirit of ſea-ſalt diſſolves gold, which other acids will not touch; ſpirit of nitre ſhakes the parts of the human *calculus* aſunder, tho no other acid will do the ſame; ſpirit of ſulphur will not work upon ſilver, which yields to all the other acids, *&c.* from whence there manifeſtly appears to be a difference in the nature of theſe acids. Mineral acids have this peculiar to them, that they are excellently adapted to diſſolve bodies of the hardeſt texture, and principally metals but particularly their mercury, wherewith they readily unite; leaving their ſulphur untouched. There is no known acid capable of diſſolving the ſulphur of iron or antimony, which is plentifully lodg'd in them both; but almoſt any acid that is well prepared, as *Aqua fortis*, *Aqua regia*, ſpirit of alum, *&c.* will take up their mercurial part, and with it ſhoot into cryſtals. This therefore is pe-

culiar

culiar to mineral acids, that they diſſolve metals with regard to their metalline nature, and thence form their vitriols; the whole art of whoſe preparation depends upon ſeparating the mercurial part of metals from the ſulphureous, which is effected by diſſolving them in acids. Thus if we would know what metal any ſulphureous mineral contains, 'tis but putting it to diſſolve in a proper acid, and the metalline part will be thereby ſeparated from the ſulphur, and may eaſily be precipitated out of the menſtruum, by preſenting another metal thereto, whereon it may act more forcibly than upon the former; which is a method employed to make an acid let fall the metal it had diſſolved. Hence gold, which contains but very little ſulphur, is perfectly diſſolved by them; whilſt lead, tin, and the ſemi-metals, which are largely ſtocked therewith, are difficultly ſeparated and formed into cryſtals. Acids in diſſolving metals, do not tranſmute, but divide them into parts of the ſame nature: Tho we cannot, for want of experiments, ſay how far they may act upon iron. But ſince in all ſolutions the action between the menſtruum and the body to be diſſolved, is reciprocal; it concerns us to ſhew how and by what means acids ſometimes receive a change in diſſolving of metals. Now if a metal has any earthy parts mixed along with it, the menſtruum muſt needs be greatly altered thereby; becauſe acid and earthy bodies exerciſe an hoſtility, and mortify one another. Such earthy metals are iron, tin, and lead, whereby the menſtruum is blunted and deaden'd. But if the ſolvend be purely metalline or mercurial, it will ſcarce work any change in the ſolvent. Such pure metals as theſe are gold and mercury, from whence the menſtruums may be recovered without any conſiderable loſs of force.

All the acid ſpirits are reducible to three capital ones; *viz.* ſpirit of ſea-ſalt, ſpirit of ſulphur, and ſpirit of nitre: and theſe three prove proper ſolvents for moſt foſſils, but particularly for ſaline and earthy bodies. But every acid will not work upon every foſſil; thus ſulphur is not diſſolved by ſpirit of ſalt nor ſpirit of nitre. All earthy ſubſtances open to acids, as ſand, chalk, the teſtaceous bodies, *&c.* but the mercurial part of metals is diſſolvable only on certain conditions. *Aqua regia*, or ſpirit of ſea-ſalt, joins it ſelf with gold, copper, antimony, and zink, marcaſite, or golden biſmuth. *Aqua fortis* works upon all the metals except gold and tin. Spirit of vitriol will not touch gold or ſilver, lead or tin, but eagerly corrodes, and thoroughly diſſolves iron and copper. Whence we ſee that the action of acid menſtruums cannot be determined *à priori*, without particular experiments.

2. *Vegetable acids*, are either native, as the juice of lemmons, and almoſt all ſummer fruits; or diſtilled, and that either before or after fermentation, as the acid ſpirit of box-wood, *&c.* and of honey, manna, *&c.* (1.) The native acid juices exert a great ſolutive force upon all the metals except gold; as alſo upon various other foſſils, as ſulphur, antimony, marcaſites, *&c.* Thus if an acid apple be cut with a knife, the blade will be corroded and turned vitriolic by the juice that is left thereon; unleſs the knife were preſently wiped. And thus, as we frequently

quently find, the juice of lemmons corrodes and changes the colour of pewter veſſels, which vinegar will not do. Nay, theſe mild and gentle native acids will more kindly work upon, and more thoroughly diſſolve, iron, tin, lead and copper, than the ſtrong acid ſpirits, becauſe of the ſulphur, or oil, which ſuch metals contain; which opens the eaſieſt to thoſe weak menſtruums. The next in order to theſe native vegetable juices, obtained by expreſſion, are, (2.) The acid liquors procured from unfermented vegetables by diſtillation, as particularly from ſome ponderous woods, as that of box, guaiacum, juniper, *&c.* which muſt be cut into chips before they are diſtilled. Theſe acid liquors diſſolve ſeveral metals, and other mineral bodies, after a particular manner; and are capable of being rendered exceeding ſtrong. If the diſtilled ſpirit of guaiacum be exquiſitely freed from its oil, which uſually adheres in great plenty thereto, it proves violently acid. (3.) The vegetable acids obtained by means of fermentation, are thoſe of honey, manna, ſugar, beer, *&c.* which turn to a vinegar that yields a very penetrating ſpirit by diſtillation. If from a hundred pints of this vinegar, there be firſt drawn ninety-five of phlegm, all that riſes after will be an acid ſpirit that will diſſolve copper into cryſtals; which being again diſtilled, afford a very ſtrong and powerful menſtruum, that greatly impoſed upon *Zwelfer*, who miſtook it for the alcaheſt of *Paracelſus*. Theſe acids diſſolve all the metals, except gold, ſilver, and mercury; but they receive ſtrange changes from ſome of them, as from iron, lead, and tin; whereby they are mortified, and almoſt deprived of their force. And if vegetable acids grow ſweet upon the body they diſſolve, they always ſuffer ſome diminution of their ſtrength; as is viſible in the caſe of lead diſſolved with vinegar: but when they acquire no ſweetneſs upon the ſolvend, as happens in their action upon copper, ſilver, and mercury, they conſtantly come off ſharper and more rigid than when they were put on. The antients talked much of an *Acetum radicatum*; that is, ſtrong vinegar poured back upon its own tartar: and indeed it is an excellent and pretty general ſolvent.

3. *Animal acids*, I believe, will, if we thoroughly conſider the thing, appear to be only notional, and to have no exiſtence in nature; for the acids which are ſometimes obtained from milk, chyle, urine or the excrements, and by ſome called animal acids, do not properly proceed from the parts of the animals themſelves, but from what they take in for their nouriſhment, and have not yet converted and aſſimilated into their own ſubſtance. It has been alledged, that ants, by diſtillation, afford an acid ſpirit; tho I could never be ſo happy as to obtain it, yet I have often diſtilled them in hopes thereof; but, on the contrary, they always yielded me a fetid alkaline one. 'Tis true, indeed, if the ants be committed to diſtillation, together with the neſts they are found in, ſomething of an acid liquor may be thence procured: this, however, is not owing to the inſects, but the leaves and other vegetable ſubſtances whereof their neſts are compoſed. In like manner, an acid ſpirit is obtainable from bees by diſtillation; but then it proceeds

ceeds not from the animals themſelves, but the wax and honey wherewith they are ſtored, and which are indiſputably vegetable ſubſtances. In ſhort, from all the pure inſects I have hitherto treated by diſtillation, I obtained a large quantity of volatile alkaline ſalt, but never any acid. *M. Homberg*, indeed, declares himſelf to have extracted an acid from human blood; but that might eaſily be the ſea-ſalt which is plentifully lodged therein *. We ſhall now add, by way of corollary to our doctrine of acid menſtruums, that *all acid ſolvents aſſume a ſaline form with the bodies they diſſolve.* Thus if the ſolution of coral, made with vinegar, be evaporated to a pellicle, and afterwards ſet in a cool place, it will ſhoot into ſaline, tranſparent cryſtals. And the ſame holds true of metalline ſolutions, made with acids; from whence are obtained the ſalts of metals, both artificial, as we ſee in the ſalt orcry ſtals of iron, ſilver, lead, &c. and natural, as in vitriols; which are nothing more than metallic glebes, corroded and diſſolved into a ſaline form by an acid ſpirit. This alſo is the caſe in the ſolution of ſtones, effected by acids; as appears by the manner wherein alum is made from chalk: for alum is no more than chalk corroded by an acid, and thereby made to appear in that ſaline form wherein 'tis found.

*The action of* neutral ſalts.

*The action and powers of adiaphorous* or *neutral ſalts*, can ſcarce poſſibly be known and determined. By neutral ſalts I mean ſuch as ſea-ſalt, ſal gem, nitre, ſal-ammoniac, borax, vitriol, alum, ſalts artificially compounded, or re-compounded, as the *Tartarum tartarizatum, Tartarum vitriolatum,* regenerated ſalts, and the *Sales volatiles oleoſi.* Almoſt all the bodies in nature are the ſubjects of their action; yet have they ſome ſpecific property, whereby they ſometimes diſſolve particular bodies that other menſtruums will not touch. Thus vitriol, ſea-ſalt, and nitre, boiled together in water, make a menſtruum that diſſolves gold into a red tincture, as we find from *Tachenius* and *Iſ. Hollandus*; tho it were in vain

* *M. Homberg*, one would have thought, proceeded with a deal of caution in the experiment, or analyſis, whereby he obtained this diſputed acid from human blood; ſollicitouſly avoiding the uſe of any ingredient, or addition, in his diſtillation, that might be ſuſpected to contain the leaſt proportion of acid. For this purpoſe he made choice of the *caput mortuum* of human blood it ſelf. The ſalt thus obtained, he thought juſtly entitled to the name of acid; becauſe upon particular experiments, purpoſely made, he found it had all the properties or characters of an acid: and one would think he was too judicious a chemiſt to be impoſed upon in this caſe by ſea-ſalt; which he could not but know was plentifully lodged in the blood; nay, himſelf expreſly tells us, that he obtained it from all animal ſubſtances. But as reaſoning, without experiments, ought never to be truſted in chemiſtry, whoſe office it is to make them, we ſhall drop all argument, and recommend this experiment to be carefully repeated, whereby ſo material a point may, if poſſible, at length be ſettled. It may give great light into the animal œconomy, and the theory of diſeaſes, and direct us to the uſe of proper remedies to know for certain whether there is or is not contained in the human body any thing deſerving the name of a real acid. *M. Vieuſſens* affirms, Dr. *Pitcarn* denies, and Mr. *Boyle*, who ſeems a neuter in the caſe, is preſſed into the ſervice, and generally charged with roundly aſſerting that there is no acid at all in the human body. But this matter will be farther cleared up by our author, when he comes to the practical part, or the proceſſes which treat the ſubjects of the mineral kingdom.

vain to expect ſuch an effect from them in the form of acid ſpirits. Thus alſo the *Tartarum tartarizatum*, and *Tartarum vitriolatum*, are admirable menſtruums for reſolving bodies into a potable form. 'Tis a wonderful experiment of *M. Homberg* and *Ludovicus*, whereby they rendered vitriol and tartar volatile; that by a mixture of native borax, and this by the addition of alum; upon which they both were raiſed into a ſalt as white as ſnow. But who is there that would believe, unleſs immediately informed by his ſenſes, that the bodies above-mentioned, which prove ſo fixed in the fire, ſhould ever be volatilized by the addition of borax and alum? The ſame may be ſaid with regard to metals, which will, every one of them, be raiſed by ſal-ammoniac (whence it has, amongſt the chemiſts, obtained the name of the *white-eagle*) and carried off into the air. When alkalies are thoroughly united with oleaginous or ſulphureous ſpirits (as in *Helmont*'s *offa alba*, which conſiſts of a pure, volatile alkali, taken up by alcohol of wine) there is thereby made a very penetrating and volatile ſope, partaking of the nature of the alcaheſt, which perfectly diſſolves all the ſulphureous metals, and all manner of ſulphurs, oils, and ſpirits. 'Twould therefore be a great point gained in medicine, if its preparations appeared in the form of a ſope, and partook of the nature thereof, like the *Sales volatiles oleoſi*, which have ſome ſort of tendency this way. Such preparations would prove admirable menſtruums as well as remedies, and diſſolve numberleſs matters; but particularly ſuch as abounded with oil and ſalt, either in the human body or out of it. Such are the virtues of neutral and compounded ſalts; for ſalts may greatly improve their force by compoſition. Thus, for inſtance, if to the vinegar of lead a ſufficient quantity of an alkali, ſuppoſe oil of tartar, be added, to take away its acidity; from hence would ariſe ſo mild a menſtruum as not to hurt the eyes, or a wounded part, if applied thereto; yet ſo powerful as to make ſuch a thorough diſſolution of myrrh, that its entire body may be taken up by ſpirit of wine; a thing otherwiſe very difficult to be done by the moſt violent means. But for what is ſaid of ſea-ſalt, as to its being an univerſal menſtruum, I could never find reaſon to expect it ſhould prove ſo. The reſult of all the experiments I have, with ſome pains and diligence, made upon it, is this, that when, by repeated purifications, I had freed it from its bituminous, oily, and fetid alkaline parts, which are largely mixed therewith, from its fiſhy and other foulneſſes given by the ſea, and by frequent decrepitations in the fire, and liquefactions in the air, brought it to its utmoſt degree of perfection, it at length run into a kind of ſaline oil; but was never ſo far changed or improved as to diſſolve all the bodies whereto I applied it.

All the vegetable menſtruums acquired by means of fermentation may be reduced to alcohol of wine. The laſt effect of all fermenting vegetables is for ever the ſame; that is, the production of this pure inflammable ſpirit. I have found, by numerous experiments, made upon different

Menſtruums *gained by means of* fermentation.

ferent kinds of vegetables, that the inflammable ſpirit they all afford, is perfectly the ſame.; manna, ſugar, honey, *&c.* yield as true alcohol as grapes. This ſpirit, when perfectly freed of its phlegm, diſſolves all aqueous and oleaginous bodies; and all the gummy, reſinous, pitchy, and ſulphureous ones too; provided they be firſt opened by alkalies: in which caſe, as was juſt now obſerved, a fine, volatile and penetrating ſope would be produced. But upon uniting an inflammable ſpirituous menſtruum with acid ſpirits, it dulcifies them, or takes off from their ſharpneſs. Thus when ſpirit of ſea-ſalt is mixed with rectified ſpirit of wine, it will not diſſolve gold, but only extract a yellow tincture therefrom. And ſpirit of nitre, the ſolvent of ſilver, joined with thrice its quantity of the ſame inflammable ſpirit, will make no ſolution, only draw a tincture from that metal much commended for its virtues in the epilepſy.

Now from the ſeveral kinds of menſtruums hitherto deſcribed, variouſly united and combined, according to the rules of art, or as accident may happen to direct, there might ariſe a new and extenſive ſet of ſolvents, with particular properties and powers: and as the whole myſtery of chemical menſtruums had its riſe from hence; we may reaſonably expect ſtill greater diſcoveries, from a due improvement of this uſeful hint.

*Anomalous menſtruums.* Beſides the menſtruums already treated of, there are others that can neither be reduced to any diſtinct general kind, nor are capable of being eaſily imitated by art; which therefore we call *anomalous* menſtruums. Such are the following.

1. *Native, or* Venetian *turpentine,* which conſiſts of a very exquiſite and ſubtile oil and ſpirit, which render it ſo exceeding penetrative and active, that if a ſcruple-weight be taken upon an empty ſtomach, and waſhed down with any proper liquid, it will, in the ſpace of two minutes, communicate its odour to the urine and other excrements. The ſame property have alſo the balſams of *Mecha*, *Copaiba* and *Peru*; which are ſo many ſpecies of turpentine. This menſtruum will diſſolve, or unite with, oils, roſins and reſinous gums; and when mixed with ſugar, honey, or manna, affords an excellent ſope diſſolvable in water, wherewith the turpentine would not before unite.

2. *The yolk of an egg,* which ſerves as a *Placenta uterina* to the chick, is a ſurprizing menſtruum, tho deſtitute of taſte and ſmell; being ground with oils, turpentine, or balſams, it renders them diſſoluble in water, wherewith ſome gums, as galbanum, and *aſſa fœtida*, may, by the ſame means, be united.

3. *The white of an egg* is alſo a ſurprizing menſtruum; for if it be firſt boiled hard in the ſhell, and afterwards ſuſpended in the air by a thread, it will reſolve, and drop down into an inſipid and ſcentleſs liquor, which is that heterogeneous and anomalous menſtruum ſo much uſed by *Paracelſus*; and will, tho it contains nothing ſharp, oleaginous or ſaponaceous,

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nacious, make a thorough solution of myrrh, which is more than water, oils, spirits, or fire it self, can effect.

4. *The gall of animals* is an inimitable sope, consisting of a very subtile animal oil, mixed up with an exceeding volatile salt; whose solutive power manifests it self, by rendering oils dissolvable in water. Physicians are of opinion, that the chyle could not be sufficiently dissolved, diluted, or prepared for its offices without it: and the bitterer it is, the fitter it always proves for such uses.

5. *Honey* and *Sugar* take to themselves balsams, turpentines, rosins, and render them potable or soluble in water. This extraordinary and surprizing virtue they have besides, that they dissolve all the gums of *Asia*, as gum-ammoniac, galbanum, sagapenum, bdellium, opopanax, *&c.* which are scarce manageable by any other menstruums. Sugar, internally used, has the faculty of dissolving, not of increasing phlegm, as is commonly supposed; for it has no tenacity of its own, only acquires it by long boiling. 'Tis the most perfect *sal oleosum*, or unctuous salt, in all nature; being soluble in water, fusible by the fire, and affording all the other signs of a salt.

We are now got thro' the several classes of menstruums, and as we went along endeavoured to shew the virtues and powers of each: but we have hitherto taken no notice of those, in a particular manner pretended to by the adept; who boast themselves masters of some grand secrets in this part of chemistry. Whether there really are such things in being, I will not pretend dogmatically to determine; but leave the authors who speak of them, to answer for themselves. But as *Paracelsus* first made mention of an universal solvent, or the alcahest, and after him *Helmont*, who was a man of uncommon candour, they have together rouzed the curiosity and industry of abundance of chemists to search after it; for which reason it will not be improper to deliver all we could ever learn of that matter. But before we proceed thereto, let us here draw the consequences that flow from the doctrine hitherto delivered of menstruums.

Corollaries *from the preceding doctrine of men-struums.*

1. We learn from what is before laid down of menstruums, that a knowledge of the *acid*, *alkaline*, or *saline* nature of any body, will not enable us to determine the action of that body upon others, or its power of dissolving them, any farther than particular experiments have shewn to be fact. (1.) Oil of vitriol and *Aqua fortis*, tho the strongest acids, will not dissolve gold, sulphur, or oil. And therefore, when we see spirit of nitre dissolve silver, 'twould be wrong thence to conclude, that it would do so by the other metals. For the fact here is, that spirit of nitre dissolves silver only; and the experiments must be severally made with it to shew whether it will touch the other metals. (2.) The fixed and volatile alkali gained from urine, will not work upon gold, silver, or mercury. *Glauber* sought for the alcahest in alkalies; but never could dissolve the mercurial part of metals with them.

(3.) Tho sea-salt be kept ever so long upon sulphur, or silver, it will not change them.

2. The action, therefore, of all menstruums is relative; and every body in nature may be accounted a menstruum with regard to the thing it dissolves. Aloes and myrrh will remain untouched in common menstruums; but if digested with regenerated salt of tartar, and afterwards joined with the saffron, they will all be readily taken up by spirit of wine, and compose *Elixir proprietatis*. But it were a strange way of arguing from hence to infer, that regenerated salt of tartar is the universal menstruum. 'Tis plain, therefore, that the action of every menstruum can only be known, and ought only to be inquired after by experiment.

3. From the dissolving power manifested by a menstruum, we cannot conclude it to be acid, alkaline, spirituous, sulphureous, or saline; for we find by experience, that hard bodies, which obstinately resist the strongest menstruums, will sometimes yield to the weaker. Mercury thoroughly dissolves the body of gold, tho it self may be applied to the naked nerves without causing pain, or otherwise manifesting it self than by its coldness. Milk will draw a ruby tincture from red coral; which is more than any acid could perform. And alkalies do not always act by absorbing of acids; for they work upon and unite with oils, and bodies that have no acid belonging to them, as flints, for instance, wherewith they compose glass. Whence it is plain, that the action of a menstruum does not let us into its nature.

4. The corrosive power of every menstruum is not absolute and universal, but relative and determinate. Thus oil of vitriol has no corrosive force with regard to gold, wax, glass and the like, upon which it makes no impression; but only with respect to those bodies it is able to dissolve. Corrosion, therefore, is always relative to the body to be corroded; nor can we properly call any body corrosive, before we know the subject it will corrode. Mercury laid upon the warm hand, will give no pain, but feel soft and smooth thereto; yet would it corrode and eat through any metalline vessel, except one of iron. Oil of vitriol, also, and mercury-sublimate, which are ranked among the strongest corrosives, will not work upon silver, crystal of the rock, sand, *&c.* Hence the antient chemists, who knew nothing of the alcahest, would say that every corrosive is so with regard to its subject, and not with regard to it self. Fire, indeed, is thought to be a general solvent or destroyer, tho we find that it destroys or carries off no body thro' which it can every way pass equably. Thus it does not change and destroy pure mercury, when the force applied thereto is allowed to act no otherwise on one part than on another: but if any particles of arsenic or cobalt, are lodged in the quick-silver, whereby the free motion of the fire is hindred; then the particles of the mercury also are raised along with them; because, in effect, these furnish the other, as it were, with wings.

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5. The hardeſt ſubjects do not always require what appear to us the ſtrongeſt and the ſharpeſt menſtruums; nor do the ſofteſt bodies always yield to thoſe menſtruums which work upon the harder: for, as we juſt now ſaw, the force of the ſolvent is relative, and to be eſtimated only with regard to the ſolvend. Thus the ſtone of the bladder, which diſſolves in ſpirit of nitre, will not be touched by oil of vitriol; tho reputed a ſtronger acid than the other. Lead opens neither to ſpirit of nitre, nor oil of vitriol; but readily to the juice of lemmons, vinegar, and that ſpirit alſo when lowered with twelve times as much water. Coral expoſed to the violence of the ſtrongeſt acids, will communicate no tincture thereto; but immediately yields its redneſs to white wax or milk. The ſpirit drawn from rye-bread will melt down ſtones and metals whilſt they are held in the hand, yet never fret or touch the skin; nor give the leaſt pain to the moſt ſenſible parts of the body. Whence we may juſtly hope a ſolvent will be found for the human *calculus*, that ſhall not fret or wound the bladder. Steel is the hardeſt of metals, and will cut them; yet will it be perfectly diſſolved by the juice of lemmons, or of citrons, which is ſo grateful and innocent to the tongue. Mr. *Boyle* tells us he had a menſtruum, and gives ſome hints whereby to diſcover it, that would diſſolve all ſtones, metals, and even gold, into a ſoft and potable liquor; the menſtruum it ſelf being exceedingly mild and gentle. The reader muſt again allow me to repeat, that we ſhould not deſpair of finding innocent ſolvents for the ſtones generated in the human body. Theſe ſtones are found lodged in the urine, gall, blood, lympha, ſaliva, *&c.* liquors which will not diſſolve them. We likewiſe know, that ſaline, alkaline, acid, ſpirituous, ſulphureous, mercurial and ſaponaceous menſtruums, work no effect upon them; but ſpirit of nitre has the power to do it; tho it unluckily happens to be a corroſive with regard to the human body. Surprizing cures, however, are daily performed by ſuch menſtruums as thoſe above-mentioned, without prejudice to the body. A child chancing to ſwallow a needle, I ordered him to drink nothing but the juice of lemmons, ſweeten'd with honey, whereby his ſtools were rendered black; and he found no farther miſchief. To a woman who had contracted a deſperate aſthma by receiving the fumes of lead, I ordered vinegar; and ſhe was cured.

6. Solvends generally change the ſolvents, as much as themſelves are changed thereby. This made the antients ſay, that every ſolvent was wearied out, or made ſluggiſh, by the ſolvend in the act of diſſolution. Hence action and reaction are equal between the menſtruum and the body it diſſolves. Thus oil of vitriol ſuffers ſo great a change by diſſolving iron, that if the ſolution be diſtilled, nothing but mere phlegm will come over. Thus fiery alkaline ſalts are ſo altered, by diſſolving flints and ſand, as with them to conſtitute glaſs; which is a taſteleſs body. Pure ſpirit of wine ſuffers a leſs change in ſolution than any other menſtruum: for tho it ſhould be diſtilled off from the bodies it diſſolves a hundred times, 'twould ſcarce be diminiſhed in its

virtue. Yet even this loſes of its taſte thereby; and the oftner it is diſtilled, the more inſipid it becomes; tho it always remains oleaginous and inflammable. *Zwelſer*, in the trifles he has publiſhed about the alcaheſt, ſays, there is a certain acid which may be drawn off unaltered after ſolution. And, indeed, *M. Homberg* informs us, that in a pint of vinegar, for inſtance, there is a very large portion of earth and water, and but a very ſmall one of acid ſalt, obtainable in a ſolid form; which being diſſolved in water, makes vinegar again. Such an acid as this, therefore, might ſuffer no great alteration by being diſſolved. Water, tho it does not eaſily admit of any alteration, is yet by diſtillation convertible into earth, as Mr. *Boyle* has tried.

7. A great degree of ſimplicity, purification, or rectification, does not always increaſe the ſtrength or power of a menſtruum, but ſometimes proves deſtructive thereof. Thus common ſpirit of wine will extract a better tincture from jalap, than that which is highly rectified; and is alſo to be prefered thereto in making *Harvey*'s tincture. Pure oil of tartar will remain diſtinct in alcohol of wine, but diſſolves in a lower ſpirit, in wine or in water. Oil of vitriol, when highly dephlegmed, will ſcarce touch iron or lead, before it is let down with water. And *Aqua fortis*, when diluted or expoſed to the air, will make a better ſolution of the calx of lead, than it would when exquiſitely purified, or kept therefrom.

8. There are ſome menſtruums that require the utmoſt degree of purity before they will operate. Thus amber neither opens to wine, nor the ſpirit of wine, tho it will to the pureſt and fineſt alcohol. It has been aſſerted, that no tincture could be gained from ſalt of tartar; but I have, by means of the higheſt alcohol, obtained a red one therefrom; very different, alſo, in taſte, from that of the ſpirit employed to extract it.

## *Of the* Alcaheſt, *or* Univerſal Menſtruum.

*Introduction to the hiſtory of the* Alcaheſt.

PAracelſus, and the elder *Helmont*, have expreſly declared in their writings, that there is a certain fluid in nature, capable of reducing all ſublunary bodies, as well homogeneous as mixed, into their *Ens primum*, or original matter whereof they are compoſed; or into an uniform, equable, and potable liquor, that will unite with water and the juices of our bodies, yet retain its ſeminal virtues; and if mixed with it ſelf again, thereby be converted into pure elementary water: whence they imagined this menſtruum could at length reduce all things to water, which, it ſelf, was incapable of any farther change. Such a declaration as this, ſeconded by the aſſeveration, or oath of *Helmont*, who religiouſly ſwears himſelf poſſeſſed of the ſecret, cauſed all the ſucceeding chemiſts ſollicitouſly to turn their thoughts and labours to find out ſuch a noble menſtruum. And the famous Mr. *Boyle* was ſo fond of it, that he frankly acknowledges he had rather have been maſter thereof than of the philoſophers ſtone; as indeed it were a thing more to be wiſhed for,

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than the power of tranſmuting metals: that great philoſopher, however, ingenuouſly tells us he had not the good fortune to poſſeſs it.

Now it is eaſy to conceive, that all bodies might originally grow from ſome firſt matter, which was once in a fluid form. Thus the primitive matter of gold is, perhaps, nothing more than a ponderous fluid; which from its own nature, or a ſtrong attraction between its parts, afterwards acquires a ſolid form. The aſſertion, therefore, of *Paracelſus* and *Helmont*, carries a ſhew of probability with it, when they ſay there is ſome one univerſal *Ens*, or original matter, that reſolves all bodies into their *Ens genitale*, or the primitive ſubſtance whereof they were at firſt created. So many are the authors who have treated of this ſubject, that a library might almoſt be collected of the books written upon the alcaheſt. *Weiderfelt*, in his treatiſe *de ſecretis adeptorum*, has made a collection of all the opinions that have been entertained about it; but 'tis manifeſt from his writings, that himſelf never ſaw the thing. *Pantaleon* alſo, with *Philalethes*, *Tachenius*, *Ludovicus*, and a thouſand others, treat of the ſame ſubject. But none of them ſpeak to the purpoſe, nor declare themſelves poſſeſſed of the ſecret, except *Paracelſus* and *Helmont*; who being the original authors, upon whom the reſt have only wrote idle comments, or fallen into ſome whimſical conceit as to this grand ſolvent, we ſhall confine our preſent inquiry to thoſe two; as judging it the readieſt way of diſcovering whatever relates to the ſubject.

*The origin of the term* alcaheſt.

The term *alcaheſt* is not peculiarly found in any language; and *Helmont* declares he firſt obſerved it in *Paracelſus*, as a word that was unknown before the time of that author. *Paracelſus*, in his ſecond book *de viribus membrorum, Cap. 6.* treating of the liver, has theſe words. *Eſt etiam* Alcaheſt *liquor, magnam hepatis conſervandi & confortandi, adeoque ab hydropicis, & ejus omnibus generibus, ab hepatis vitiis ortis, præſervandi vim & efficaciam habens. Ejus proceſſus eſt, ut à coagulatione reſolvatur, & iterum coaguletur in formam tranſmutatam, ſicut de coagulando, & tranſmutando docet. Tunc enim ſi ſuum ſimile ſuperaverit medicina, fit hepatis medicinis omnibus ſuperior. Et ſiquidem hepar ipſum ruptum & diſſolutum foret, loco tamen totius hepatis is eſt, non ſecus ac ſi nunquam ruptum & ſolutum fuiſſet. Quicunque ergo medicinæ operam datis, ſummo ſtudio id anniti debetis, ut* Alcaheſt *præparare diſcatis, propter averſionem multorum morborum qui ab hepate oriuntur.* The direct and literal *Engliſh* whereof, runs thus: "There is alſo the liquor "*alcaheſt*, which proves of great power and efficacy in preſerving "and comforting the liver; as alſo in curing hydropical and all other "kinds of diſeaſes ariſing from diſorders of that part. Its proceſs is, "to be diſſolved from coagulation, and again coagulated into a tranſmuted "form; as is taught in the proceſs of coagulation and tranſmutation. "But then if the medicine ſhall once have conquered its like, it becomes "ſuperior to all the medicines adapted to the liver: and tho the liver "it ſelf were broken and diſſolved; yet this medicine would ſupply its "place, as well as if it never had been ſo broken and diſſolved. "Whoever, therefore, ſtudies phyſic, ſhould earneſtly endeavour to learn

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"the preparation of the *alcaheſt*, that he may know how to put aſide "the many diſtempers which ariſe from the liver." This ſingle paſſage of *Paracelſus* it muſt have been which excited the chemiſts who ſucceeded him, to ſuch a vigorous inquiry after the *alcaheſt*: for from a particular peruſal of his works, I could diſcover no more than another indirect expreſſion about it, importing leſs of the ſame ſubject than that juſt now delivered from him, and one ſhort ſentence beſides, where he ſpeaks of the *alcaheſt* as a ſolvent for ſome bodies that required calcination, *ſolvere quædam calcinanda*. It might, therefore, appear ſurprizing, that *Helmont* ſhould barely from hence take occaſion to break out ſo laviſhly in the praiſes of the alcaheſt, which is not here recommended as an univerſal menſtruum, were we not informed, that in his travels thro' *Germany*, he picked up all he could learn about it from the diſciples of *Paracelſus*. Now we are well aſſured it was a frequent practice with this author, to tranſpoſe the letters of his words, and to make uſe of abbreviations, or other ways of concealment, in his writings. Thus for *tartar* he would write *ſutratar*, for *Nitrum*, *Mutrin*; ſo that *alcaheſt* may poſſibly be a word wrote after the ſame manner: whence ſome have imagined it to be formed of *Alkali eſt*; and accordingly, that it was the alkaline ſalt of tartar volatilized*: But *Helmont* ſeems expreſly to deny it, by ſaying, "If you "cannot obtain to the alcaheſt, learn to make ſalt of tartar volatile." Others would have it to be the *German* word *Algeiſt*, that is, wholly ſpirituous or volatile: and, indeed, the proceſs mentioned of it, is the ſame with that of a ſpirit. There are ſome too, of opinion, that *Alcaheſt* is taken from *Salts-geiſt*, which ſignifies ſpirit of ſalt; for the univerſal menſtruum, 'tis ſaid, is to be wrought from water: and *Paracelſus* himſelf calls ſalt, the centre of water, wherein "metals ought to "die and loſe their bodies." And in effect, ſpirit of ſalt was the great menſtruum he uſed on moſt occaſions; as appears from his *Archidoxa*, in the nine former books whereof he reveals all his ſecrets, except his *principal ſpirituous ſolvent*, or *univerſal menſtruum*, which in the firſt he promiſed to diſcloſe. This occaſioned the tenth book to be diligently and ſollicitouſly inquired after, wherein a revelation of the grand ſecret was expected; and at length the biſhop of *Cologn* found what paſſes under that name. The commentator upon *Paracelſus*, who gave a *Latin* edition of his works at *Delft*, tells us, the *alcaheſt* was mercury entirely converted and prepared into a ſpirit. And this is all that ever I could find as to the term *alcaheſt* in the writings of *Paracelſus* and his tranſlators. But the better to clear up this grand affair, we will, in the next place, inquire if any ſynonymous words have been uſed for it.

*Words of the ſame import with the* Alcaheſt.

*Paracelſus* never ſpeaking expreſly of the *alcaheſt* but in the paſſage we have quoted from him, has made uſe of no ſynonymous term or phraſe

* This ſeems to have been the ſettled opinion of *Glauber*; who indeed performed ſurprizing things with ſuch a menſtruum, upon ſubjects of all the three kingdoms.

phrase for it. Our recourse, therefore, in this inquiry, must be to the elder *Helmont*; who

1. In the *Elziver* edition of his works in *quarto*, given by his son, *A. D.* 1652. *p.* 377. *n.* 3. mentions the *alcahest* by the compound name of *ignis-aqua*, *fire-water*. But in this place he seems to mean the *circulated liquor* of *Paracelsus*, which he terms *fire* from its property of consuming all things; and *water* on account of its liquid form; and therefore by joining the two words together expresses both its properties at once.

2. *Pag.* 45. *n.* 15. and *pag.* 119. *n.* 89. he calls it *Ignem Gehennæ*, *infernal fire*; a word also made use of by *Paracelsus*. In the place first cited *Helmont* is treating of original, that is, elementary earth, " Which, " *says he*, when perfectly purified and freed from all foreign matter, " can be changed by no body in nature except the *infernal fire*, which " will reduce it into the same fluid whereof it was originally composed." Whence it is plain, that this *infernal fire* was an artificial thing; and the same with the *alcahest*.

3. *Pag.* 628. *n.* 2. he calls it *Aquam solventem*, a dissolving water; and here says, " There is another synonymous word for it in *Paracelsus*, " namely *sal circulatum*, which reduces all tangible bodies into the " liquors they were made from."

4. *Pag.* 380. *n.* 24. he entitles it *Summum & felicissimum omnium salium*; " the principal and most successful among salts, which having obtained " the highest degree of simplicity, purity, and subtilty, alone enjoys the " faculty of remaining unchanged and unimpaired by the subjects it works " on, and of dissolving the most stubborn and intractible bodies, as " stones, gems, glass, earth, sulphur, metals, *&c.* into real salt, equal in " weight to the matter dissolved; and this with as much ease as hot " water melts down snow. This salt, also, *continues he*, by being several " times cohobated with *Paracelsus*'s *sal circulatum*, loses all its fixedness; " and at length becomes an insipid water, equal in quantity to the salt it " was made from." Now *Helmont* has given a very accurate description of salt, and consequently could not but know what it was; so that we cannot well mistake him when he calls the *alcahest* a salt.

5. *Pag.* 43. *n.* 11. and *pag.* 157. *n.* 6. he gives it the name of *Sal circulatum Paracelsi*, because made by a circle of distillations and cohobations; and says he had two kinds thereof, a less and a greater, which latter is that of *Paracelsus*, and esteemed by *Helmont* the same with the *alcahest*.

6. *Pag.* 94. *n.* 27, 28. he delivers, tho very obscurely, the whole composition of the *alcahest*, with all its virtues; where he calls it *latex*, which properly signifies pure, transparent, running water. *Helmont*, therefore, being a thorough master of the *Latin* tongue, must mean by that word, as here applied, *transparent salt reduced to a fluor*. The passage being very remarkable, we shall give it in the original. *Chemia indagando sollicita est corpori, quod tantæ puritatis symphonia colluderet nobiscum, ut à corrumpente nequiret dissipari; ac tandem stupefacta est* religio, reperto

latice, *qui ad minimos redactus atomos naturæ possibiles, cœlebs omnis fermenti connubia sperneret.* Which words may be thus rendered: "Chemistry busies her self to find out a body so pure, to make harmony with us, "as that it self should remain incapable of corruption or dissolution; and "at length *religion* stood amazed at the discovery of a pure, limpid, run-"ning water, which, tho reduced to the smallest particles in nature, "keeps it self unviolated; refusing the embraces of every ferment." By *religion* the author here understands the chemical religion, or the doctrine and practice of chemists.

7. *Pag.* 88. *n.* 27. he gives it the title of *water;* where he thus expresses himself: "I know a certain *water*, which I cannot think proper to re-"veal, wherein all manner of vegetables are changed into an exhalable "juice, without the least sediment falling to the bottom of the contain-"ing glass: and this juice, when applied to salts, is wholly reducible "into insipid and elementary water." He also quotes the first *chapter* of the second *book* of the *Maccabees*, where mention is made of a water that took fire, to this effect: "Now when the sacrifice was burnt, "*Nehemiah* commanded the great stones to be sprinkled with the residue "of the water; which, when it was done, there was kindled a flame "of them also; but it was consumed thorough the light that shone "from the altar. So when this matter was known, it was told the "king of *Persia*, that in the place where the priests which were led "away, had hid fire, there appeared water instead of fire, and that "*Nehemiah* and his company had purified the sacrifices withal." And to this liquor he compares his alcahest, telling us it was thick, a perpetual fire like the vestal, and not unlike what is describ'd in the chapter of the *Maccabees* already referred to. So much for the synonymous terms which have been used for the alcahest; but if we would know what our two grand chemists meant by their universal menstruum, we must not rest our inquiry in the etymology and phraseology of the word, but search into the origin, properties, and characters of the thing; and, by comparing together the obscure passages of both writers concerning it, see if we cannot make one explain the other; so as to let us a little into this grand secret.

*The origin of the alcahest.*

1. *Helmont* is express that this menstruum is entirely the product of art, and not of nature; as appears from *pag.* 56. *n.* 12. of his works; where he says, "Tho an homogeneal part of elementary earth may be arti-"ficially converted into water, yet I deny that the same can be done "by nature alone; for no natural agent is able to transmute one ele-"ment into another." And this he offers as a reason why the elements always remain the same in quantity. *Helmont*, as well as *Paracelsus*, took water for the universal instrument of chemistry and natural philosophy, and earth for the unchangeable basis of all things, which, according to him, was created by God to give form to bodies; that fire was designed as the efficient cause of all things; that seminal impressions were lodged in the mechanism of earth; and that water, by dissolving

diſſolving and fermenting with this earth, as it does by means of fire, brings every thing to light; whence originally proceeded the animal, vegetable, and mineral kingdoms; even man himſelf being thus at firſt created, agreeably to the account of *Moſes*. Nor does there appear any abſurdity in all this. Earth, therefore, according to him, was naturally indeſtructible; yet convertible into water by the action of the alcaheſt, which, therefore, is not a natural body, but an artificial preparation.

2. *Pag.* 94. *n.* 28. he declares the alcaheſt to be unobtainable without the *labor ſophiæ*, the work of wiſdom, or ſecret knowledge of the adept, whereby they prepare the philoſopher's ſtone; which he tells us is incomparably more eaſy to procure than the alcaheſt: and of the great difficulty and labour requiſite in its preparation, he expreſſes himſelf to this effect: "No body ever yet made a cure of the leproſy "without the aſſiſtance of the *alcaheſt*, which cannot be obtained "without a tedious and laborious operation: and however great the "skill of the artiſt may be, and whatever pains he may take, yet ſhall "he never poſſeſs this menſtruum but by a particular favour of provi-"dence. Great is the *labor ſophiæ*, the work that has made a breach "into nature, and ſhewed us an anomalous preparation, that without "mixing with any ferment, riſes a ſerpent different from it ſelf, dies "by its own bite, but revives again, and yields to death no more. "The *ludus* of *Paracelſus* may be made in a moment, but the diffi-"culty is to prepare the *alcaheſt*; than which nothing in all the art "of chemiſtry is more laborious." And thus much may ſerve to ſhew the errors of thoſe chemiſts, who, ſince *Helmont*, have ſeverally pretended to the *alcaheſt*. *Ludovicus*, *Starkey*, *Zwelfer*, *Glauber*, &c. thought themſelves poſſeſſed of it, without taking the pains that *Helmont* declares to be neceſſary in its preparation. *Baſil Valentine* and *Zwelfer* judged it to be ſpirit of vinegar rectified from verdigreaſe; *Starkey* thought he diſcovered it in his ſope; and others would make us believe they found it in fixed alkalies, or acquired it at ſome very eaſy rate. But ſo far were ſuch people from having had the ſecret of the alcaheſt, that they knew not how to go about its preparation; and wanted a true notion of the thing. Whoever expects to obtain it in good earneſt, may take *Helmont*'s word for it, he muſt not only beſtow uncommon pains, but alſo prove very happy if he obtains his end. And tho we were perſuaded a man knew the ſecret of the philoſophers ſtone, we ſhould ſtill be cautious how we believed him poſſeſſed of the alcaheſt.

Let us next inquire into the diſtinguiſhing marks and characters of the univerſal menſtruum. *The properties of the alcaheſt.*

1. Its firſt character, or property, is to diſſolve and change all ſublunary bodies; water alone excepted.

2. The changes it brings upon them proceed in this order. Every ſubject expoſed to its operation, is firſt converted into its three principles; ſalt, ſulphur, and mercury, and afterwards into ſalt alone; which then becomes volatile, and is at length wholly turned into inſipid water.

3. But this operation proceeds not equally in all bodies; metals, and above all, that particular ſand which lies where the pureſt ſprings take their riſe, below the earth, being diſſolved by it with greater difficulty than other bodies. If any one, therefore, pretends to the alcaheſt, bid him firſt diſſolve this ſand with his menſtruum, before you aſſent to his aſſertions about it.

4. The manner of making the experiment, is to touch the body propoſed to be diſſolved, once or twice with the pretended alcaheſt, whilſt the ſubject is contained in a proper veſſel; and if the liquor be genuine, the body will thereby be converted into its own quantity of ſalt. Thus if it were applied to an ounce of ſand, gold, or mercury, you would obtain by the experiment an ounce of the ſalt of each body, without any mixture of the menſtruum, or change being wrought thereon. See *Helmont*'s works, *p.* 88. *n.* 24—28. *p.* 265. *n.* 11.

5. It does not deſtroy the *ſeminal virtues* of the bodies diſſolved thereby. Thus gold is, by its action, reduced to a ſalt of gold, antimony to a ſalt of antimony, ſaffron to a ſalt of ſaffron, *&c.* of the ſame *ſeminal virtues*, or characters with the original concrete. By *ſeminal virtues Helmont* underſtands thoſe virtues which depend upon the conſtruction or mechaniſm of a body, and which make it what it is. Thus if a pound of cinnamon were, by the alcaheſt, reduced to a pound of ſalt, this ſalt would retain the ſmell and taſte of cinnamon; tho it would now become ſoluble in water, and would run by the fire. Hence an actual and genuine *Aurum potabile* might readily be gained by the alcaheſt, as converting the whole body of gold into a ſalt retaining its ſeminal virtues, and being ſoluble in water. See *Helmont*, *p.* 25. 43. 88.

6. Whatever it diſſolves may be rendered volatile by a ſand-heat, or the heat of a *Balneum Mariæ*, as we learn from a very remarkable paſſage of our author, *p.* 88. which take in the following words. "I put a "charcoal of oak into a glaſs veſſel, with an equal quantity of a certain "water, and ſealed the glaſs hermetically; whereby, in three days "time, the entire coal was, with the heat of a bath, converted into "two tranſparent liquors, of different colours; which being diſtilled "off in a ſand-furnace, with a fire of the ſecond degree, the bottom "of the glaſs appeared as pure and clean as if it had juſt been taken "out of the glaſs-houſe kiln. Theſe two liquors afterwards roſe by "the warmth of a *Balneum*, equal in weight to the matter of the coal; "whilſt the liquor which had procured the diſſolution, remained at "the bottom of the glaſs, without having loſt of its weight or virtue." If any one, therefore, pretends to the alcaheſt, let him do the like, or paſs for a deceiver. The univerſal menſtruum, he tells us, may alſo fix ſome bodies, as mercury for inſtance, ſo that they ſhall not eaſily recover their volatility. See *Helmont*, *p.* 380. *n.* 24. *p.* 776. *n.* 11. *p.* 628.

7. If, after having once volatilized the ſolvend, it be diſtilled therefrom, the body is left pure inſipid water, equal in quantity to its original ſelf, but deprived of its ſeminal virtues. And this muſt be the caſe of

all the bodies in nature. Thus if gold be diſſolved by the alcaheſt, the metal firſt becomes ſalt, which is potable gold; but when the menſtruum is diſtilled therefrom, 'tis left mere elementary water. Whence it appears, that pure water is the laſt production or effect of the alcaheſt. See *Helmont*, *p.* 43. 56. 780. *n.* 25.

8. It ſuffers no change or diminution of force by diſſolving the bodies it works on; and therefore ſuſtains no rea-ction from them; being the only immutable menſtruum in nature. Our author calls it, "A "virgin that refuſes the embraces of every ferment, becauſe it can find "nothing like it ſelf wherewith to unite; and the principal of ſalts that "has the power of pervading all bodies, (whilſt it ſelf remains un-"changed thereby." Hence he calls it, "*Liquorem æternum*, the immor-"tal liquor; which, *ſays he*, has no equal; for as there is in all nature "but one burning and conſuming fire; ſo is there but one liquor ca-"pable of diſſolving all bodies into their primitive matter, without "receiving the leaſt change or diminution of its virtues." See *Helmont*, *p.* 45. *n.* 15. *p.* 94. *n.* 27, 28. *p.* 678. *n.* 12. *p.* 628. 265. *n.* 11. *p.* 628. 678. *p.* 780. 788.

9. 'Tis incapable of mixture, and therefore remains free from fermentation and putrefaction; coming off as pure from the body it has diſſolved, as when firſt put thereon; without leaving the leaſt foulneſs behind it: for it acts no otherwiſe than a peſtle does in a mortar, by grinding to pieces the bodies whereto it is applied, it ſelf remaining unaffected or unchanged by the action. See *Helm.* *p.* 94, *&c.*

10. 'Tis exhalable, or may be raiſed, by a ſand-heat, but not by the heat of a *Balneum*, as we learn from the diſtillation of the wood-coal, diſſolved by means of it; which ſtrange property ſeems repugnant to ſome of thoſe above-mentioned. See *Helm. p.* 56. 88. 628. 634. 766, *&c.*

11. Laſtly, notwithſtanding what was ſaid of its immutability, 'tis not abſolutely incapable of change; but may be altered and ſubdued by its equal: and ſuch an equal our author declares it has, tho he never deſcribes it; which, therefore, muſt be a body that eludes the force of the alcaheſt, changes its nature, and deſtroys its virtues. See *Helm.* *p.* 265. *n.* 11.

The properties here delivered of the alcaheſt, are extracted from the writings of the elder *Helmont*; but neither thoſe, nor all the information to be gained from the younger, will enable us to form any ſolid and ſatisfactory judgment about this ſurprizing menſtruum. The ſon being frequently queſtioned by his friends concerning the immortal liquor of his father, always ſtudied to return evaſive anſwers; and left them in the dark as to the truth of the thing. But when he was once, at my requeſt, entreated to ſay whether his father actually poſſeſſed ſuch a menſtruum or no, he acknowledged he knew not; but ſaid that his father often boaſted of more than he could perform. Theſe properties of the *alcaheſt*, may furniſh us with a criterion whereby to examine the pretenſions of thoſe who would be thought to have got poſſeſſion of

of the fecret. If any man pretends to an *alcaheft* of a different kind from that we have here defcribed, it lies upon him to fhew how he applies the term, and what are the effects and properties of his particular preparation; but whoever would perfuade the judicious that he has obtained the *alcaheft* of *Paracelfus* or *Helmont*, muft fhew that it bears the feveral marks and characteriftics peculiar to that liquor: and if it appears to have the feveral properties above laid down, you may fairly conclude it to be the genuine *alcaheft* of *Helmont*.

Many are they who have pretended to this extraordinary menftruum. *Starkey*, that excellent chemift, difciple to *Helmont*, and friend of Mr. *Boyle*, was, as well as fome others, of opinion, that it might be a preparation from putrefied urine. Hereto they were led by thofe paffages of *Helmont*'s works wherein he expreffes himfelf to this effect: " Wifdom " defpifes thofe who are averfe to work upon putrefied urine." And fpeaking of the *ludus*, that is, the human *calculus*, he fays, " Putrefied " urine will diffolve the ftone." But he could not mean by thefe or the like expreffions, that putrefied urine was really the alcaheft; becaufe urine, in what manner foever it be treated, always has fomething fulphureous or faline mixed therewith; and confequently would give a foulnefs to the bodies it diffolved, and be altered by them; which is directly oppofite to the nature of the alcaheft. And fpirit of urine, being an alkali, is for that reafon expresly declared by *Helmont* not to be the thing. All the other preparations from urine would likewife fuffer a change. The oil of urine may be tranfmuted, and the *offa alba Helmontiana* is alterable by acids; characters no way comporting with the alcaheft. The like we muft alfo fay of *phofphorus*; which has therefore been taken for the alcaheft, becaufe *Helmont* defcribes that univerfal folvent as a thick, fhining, fire-water; but this will unite with *Aqua fortis*, fly off, and lofe its virtue in the air, flame and be entirely confumed by the fire, mix with oils, and not fix mercury. Others will have it to be a preparation from falt of tartar; but *Helmont* is exprefs to the contrary, as appears by the following words: " Whoever it is that practifes the art of phyfic, and has a concern " for his neighbour's welfare, let him learn to prepare fuch a folvent " as is homogeneal, unchangeable, and able to reduce all its objects " to their original liquid matter, whereby he will obtain the very " internal effences of things, and fee their qualities and difpofitions; " but fuch as cannot attain to this fecret, ought, at leaft, to learn " how they may render *falt of tartar* volatile; by means whereof they " may make uncommon diffolutions." *Helm. p.* 43. 56. *p.* 78. *n.* 25. This falt alfo will receive a change both from acids and oils.

*The author's opinion with relation to it.*

If I may be allowed to fpeak my opinion in this affair, I cannot believe the alcaheft was ever obtained from vegetable or animal fubftances; but, if at all, either from falt or mercury. Salt appears to have afforded *Paracelfus* an univerfal menftruum; and in the tenth book of his *Archidoxa*, publifhed by the bifhop of *Cologn*, *cap.* 14. where he treats of

of the preparation of magisteries; we find words to this effect: "In "our other writings we have sufficiently shewn that the sea, or water "is the great element of nature; being the seed of all things, and the "true mother of metals; which is what no body had observed be-"fore us; all other authors deriving their origin from sulphur, mer-"cury, *&c.*" *Helmont* also agreed with him in opinion, that water was the mother of all metals. But then they tell us, that this sea-water has a quinteſſence, which is its salt, which when reduced to its highest possible degree of purity and simplicity, seems to be that first menstruum of *Paracelsus*, which turns mercury into water. The method of making this menstruum, *Helmont* thus describes: "Take two parts of the element "of water, or sea-salt, which has never felt the fire, mix it with one "part of horse-radish water, and purify them together, for a philoso-"phical month, and the salt will thereby be converted into a kind of "oil, supposed to be the *sal circulatum* of *Paracelsus*, and an universal "solvent, which may properly enough be called a spirit of salt." But this does not appear to be the greater *sal circulatum* of that author: for it will not produce the effects ascribed thereto. I have my self made the experiment, and find the digestion of the salt will succeed, if treated after the manner directed in the process. That *Paracelsus*'s second menstruum, or grand universal solvent, was also a spirit of salt, seems countenanced by *Helmont*, who in his fourth chapter *de primo Ente*, bids us "dissolve mercury in the sea, that is, in sea-salt, and "putrefy, that is, digest, it when dissolved, till anomalous fæces fall "therefrom." *Paracelsus* farther says, "that mercury is an element ge-"nerated from sea-salt, which it self is composed of water; that all "metals and minerals are made from mercury; that every body ought "to be dissolved in its own menstruum, and first to be killed by that "wherein there is life; that all things may be composed of water, and "meliorated thereby, whence at length it self may be converted into "the universal medicine, or the philosophers stone." *Archidox. Lib.* 10. And *Helmont* places the principle of indestructibility in the *nucleus* of mercury. The process for the second *sal circulatum* of *Paracelsus* begins thus: "Run sea-salt often in the air, and dry it again, after-"wards digest it with horse-radish, distil and reverberate it in a retort, "then dissolve it in more sea-salt, digest it again with horse-radish, "distil and repeat the several parts of the operation till the whole "matter becomes a coherent mass, and all the fixed salt remains at "the bottom; then *sublime*, &c." See *Paracelf. Archidox. lib.* 10. This operation is exceeding tedious, laborious, and intricate. I have in the space of two years made above a hundred experiments in order to obtain the menstruum it promises; but when, at length, I thought my self almost possessed of it, I could go no farther than to the subliming part; for I never found out what it was to *sublime* a pure fixed salt in sea-salt. We see then that *Paracelsus* seems to have had two kinds of principal menstruums, a saline one, or sea-salt rendered exceeding pure and subtile,

 and

and another that was metalline, consisting of mercury converted by the former into a mercurial water; which proving capable of dissolving all things, might possibly be the *alcahest*. And this is all I could ever gather from the writings of *Paracelsus* and *Helmont*, with relation to the universal menstruum; which, from their times, has employed the studies and labours of so many famous chemists, with great expences, to discover.

Having gone thorough the subject of menstruums, and explained every other part of our definition at first laid down, except what relates to instruments properly so called, we come now to the consideration of these. Chemistry we said was an *art that by means of* certain instruments *changed sensible bodies, capable of being contained in* vessels, *so that the alterations they underwent might become visible*. Whence all these changes are to be made in *vessels*, by means of *certain instruments*, which, therefore, 'tis in the last place, our business to describe.

## Of INSTRUMENTS, *properly so called.*

*Chemical instruments, what.*

ALL the parts of the *materia chemica*, whilst under examination, must be contained in proper *vessels*, to keep the matter from running into, or mixing with the fire, or fewel, employed; and these vessels ought so to restrain, moderate and determine the heat upon the bodies exposed thereto, that the operations may receive no hindrance: which end can only be obtained by means of proper chemical *instruments*. *Proper chemical instruments*, therefore, *are the bodies by means whereof the moving cause, or fire, is applied and determined to the subjects proposed to be changed, in a manner capable of effecting that change.* Such instruments are chemical *vessels* and *furnaces*.

## CHEMICAL VESSELS.

*Chemical vessels, what.*

*CHemical vessels are hollow bodies fitted to contain the subjects to be changed, as well during the time of their change, as before and after it is effected.* These vessels differ from one another in respect of their matter and figure; and are made of three different bodies, *metal*, *earth*, and *glass*.

*The metalline.*

*Metalline vessels* have two inconveniences; being apt to foul or change the nature of the subject, as particularly of acids, which will corrode them; and fusing with a violent heat, which would soon have this effect where tin and lead are concerned. But when neither of these inconveniences is to be feared, metalline vessels are the most useful; and will suffer nothing to transude thro' their pores. They are generally preferable when they can be defended from the coldness of the air, which might happen to crack or split them; for they will endure a great violence of fire without being destroyed thereby; especially if made of iron that has been once fluxed; which will cause it to sustain twice

twice the heat it otherwiſe would do; tho even this ſtout metal will at length begin to vitrify.

*Veſſels* of *earth*, provided they will neither flow nor vitrify in the fire, are admirable. Of this matter, or the powder of earthen-pots, are made *crucibles*, and *Haſſian* retorts, which may be uſed in thoſe operations that require the greateſt violence of fire; tho they will be melted down by a burning concave. They are likewiſe ſubject to waſte alcalies, to be corroded by acids, to be calcined by the fire, and to let ſpirits eſcape thro' their pores in diſtillation; for which reaſons, they are only proper to be employed in the fuſion of metals. Of all other earthen veſſels, thoſe of porcelain appear the moſt excellent; becauſe they ſuffer no alteration from what they contain; tho even theſe melt and crack with heat; but eſpecially if they are glazed. Veſſels of chalk alſo may have their uſe; but theſe are diſſolvable by acids, unleſs kept in a very ſtrong fire. This kind of veſſels are employed by thoſe perſons at *Amſterdam* who diſtil very large quantities of ſpirit of nitre, oil of vitriol, *Aqua fortis*, &c. But if they be, for ever ſo little a while, expoſed to the cold air, with acids in them, they preſently crack or fall to pices. *The earthen.*

*Glaſs-veſſels* ſhare many advantages: they do not defile or mix with the bodies they contain; nothing hitherto appearing to diſſolve them but ſtrong ſpirit of ſalt; not even mercury, the ſtrongeſt acids and alkalies, or the ſulphur of arſenic. Theſe alſo are impervious to ſtrong ſpirits, as *Aqua fortis*, ſpirit of nitre, and other acids, which could not be contained in metalline veſſels. *Helmont* declares, that even his *alcaheſt* might be expoſed to the fire in a glaſs-veſſel. But the matter whereof theſe veſſels are made, ſhould not be the white, cryſtalline glaſs, which is apt to crack, and ſoon flows in the fire, by reaſon of the large proportion of fixed alkali contained therein; which alſo gives an urinous taſte to ſome bodies. The green glaſs is the ſtrongeſt, moſt durable, and fitteſt for chemical uſes; as containing the greateſt quantity of earth. This advantage is peculiar to glaſs-veſſels, that being tranſparent, we may, by means thereof, view the ſubject during the time of an operation, and obſerve, thro' their ſides, the ſeveral changes made by every ſtep of the proceſs. Their greateſt imperfection is, that they cannot endure a higher than the third degree of fire, without growing ſoft, and melting; and can, therefore, never ſerve in the fuſion of any metals, unleſs of lead or tin. But in any degree of heat below the third, we may very commodiouſly make uſe of glaſs-veſſels; ſince, of themſelves, they neither bring any change upon the objects, nor ſuffer them to tranſude, or eſcape. *And thoſe of glaſs.*

The *figure* of veſſels differs with the uſes for which they are deſigned. Chemiſts, in all their operations, have occaſion for no more than two kinds of veſſels, viz. *containing* and *receiving*. They require only a veſſel that ſhall *contain* the body they deſign to change; and another to *receive* it after it is changed. Now the veſſel containing the matter to be *Their figure.*

be changed, muſt either be expoſed to a cloſe or an open fire: in the latter caſe, only ſingle veſſels, ſuch as pans or diſhes, melting-pots, crucibles, teſts, *&c.* are employed. But when things are committed to a cloſe fire, numberleſs different veſſels may be uſed; tho' all of them are reducible to two kinds, *viz.* the *cylindrical* and the *conical.* Veſſels of a true cylindrical form are very rarely employed in chemical operations. *Cucurbits* come the neareſt to it, which are frequently made choice of where a diſtillation is deſigned to be uniformly carried on. Conical veſſels are of two kinds; the figure of the cone being erect in ſome, and in others inverted. The former riſe taper from a broad circular baſe; whereby the ſides approach one another the neareſt at the top. These we make uſe of when we deſign to hinder the aſcent of the bodies expoſed to the heat: for the inclination of the ſides of the veſſel will here prove an obſtacle to the riſe and eſcape of the fumes which might otherwiſe fly off. The latter, or inverted conical veſſels, riſe broad from a narrow circular baſis, and open in a wide mouth at laſt. And theſe are employed, with a view, contrary to the former, to ſeparate and obtain the more fixed parts of bodies from thoſe which are lighter and more volatile: becauſe the ſides of theſe veſſels obſtruct not the riſe and avolation of the more fugitive matters ſubmitted to the action of the fire. A true knowledge of the nature, uſes, and application of all the chemical veſſels depends upon rightly conceiving the reaſon of their different ſtructure. If a veſſel were perfectly cylindrical, it appears from geometry and hydraulics, that the fire, acting in ſtrait lines upon any ſubſtance lying at the bottom thereof, would give it a motion directly upwards; and that this motion would not be reſiſted or altered by the ſides of the veſſel. But ſhould theſe ſides converge towards the mouth, and ſo give a conical form to the veſſel, much of the matter that was raiſed by the fire would impinge, or ſtrike againſt them, and thereby be obſtructed in its elevation; for no more parts would now be carried off than what never ſtruck againſt the ſides, or could overcome the reſiſtance they make to the force wherewith ſuch parts tend upwards. If, therefore, the mouth of the veſſel were infinitely ſmall, no particle could eſcape thereat; and all thoſe that roſe would then fall back again; on the other hand, if the veſſel had no ſides at all, but was entirely flat, or every way perfectly open, it ſelf would not in the leaſt obſtruct the riſe and eſcape of the volatile parts. Hence we ſee the reaſon why cupels are made flat, with little or no ſides belonging to them; and why diſtillation is the eaſier performed in ſuch veſſels as are both low and wide. Diſtillation, as commonly conceived, is the aſcent of certain moiſt particles in the form of a vapour; and conſequently muſt proceed in proportion to the height, and the obſtacles that might any way retard it: it will therefore always be in a ratio compounded of the direct proportion of the orifices of the containing veſſels, and the reciprocal of their altitudes. Thus if the ſame matter were, with the ſame heat, to be diſtilled in two cucurbits of equal heights, but of

See Fig. 10 and 11. Plate I.

of different diameters at their mouths, the quantity of liquor gained by the operation would be as those diameters. Those bodies, therefore, which are distilled with difficulty, should be committed to a broad and low vessel; and such as are very volatile, to a narrow and a tall one. Thus by nicely adjusting and suiting your vessels, rectified spirit of wine might be brought to boil below, whilst no particle should rise so high as to escape into the air; or mercury be agitated with a violent fire without suffering any loss, *&c.* And by this means it is, that some uncommon and extraordinary things have been performed in chemistry.

The principal vessels requisite in the practice of our art, and such as we shall hereafter have occasion for, are those which follow.

1. A *cucurbit*, which is a bellied vessel, broad at bottom, but narrower upwards, called in the *Dutch* language by the same name with *Hercules*'s club, from the resemblance it bears thereto; but the *Latin cucurbita* originally signifies a *gourd*, whose figure is not ill represented by our vessel; which, however, sometimes differs from it self; for it may have a neck of equal diameter with the bottom, or slenderer or wider than that. This vessel, therefore, is fit for those distillations wherein the vapour is designed to rise high. *Cucurbit. Plate I. Fig. 1.*

2. A *matras*, otherwise called a *bolt-head*, or *egg-vial*, is a vessel of a capacious, roundish or cylindrical bottom, joined to a slender neck, and consequently a species of the *cucurbit*; having only a narrower mouth and a longer neck than that. If the neck of one matras be inverted into that of another, the two together make what is called a *circulatory vessel*. And that instrument, or vessel, which is placed upon the *cucurbit* or *matras*, to keep in or condense the vapour in distillation, is termed a *head*; as in the alembic, which we shall see presently. The *matras* is of use when no separation is intended to be made, by the rise of vapours thro' the neck, as in extracting tinctures, *&c.* *Matras. Fig. 2.* See *Fig. 9.*

3. A *retort* is a bellied vessel, with a bent or angular, and slender neck; being an artificial compendium or improvement of the two former; for it answers all the purposes of those, without the assistance of a head; which they sometimes require: and distillation may, by means of it, be performed in a simple manner; this requiring nothing to fit it for that purpose besides a receiver. *Retort. Fig. 3.*

4. A *receiver* is the vessel employed to arrest and contain the body submitted to a chemical process or operation, after it is changed by the fire. This vessel may be any convenient thing, and is usually no other than a matras, whose mouth admits, and receives the bent neck of the retort, thro' which the changed matter flows into the belly of the receiver. *Receiver. Fig. 4.*

We may now understand the contrivance and nature of that manner of distillation, whereby strong, acid, or saline spirits are obtained. This is performed by a set of perforated vessels, or long-necks, exactly joined and fitted one into the neck of another; and serving as one long continued retort, that ends at last in a receiver: by which means the journey of *Long-necks.*

the vapours being lengthened, they are cooled in the paſſage, tho they never riſe high. Were it not for this contrivance, which gains length to the retort without adding to its height, and may be continued out to any diſtance we pleaſe, ſtrong acid ſpirits could never be obtained with any tolerable profit or ſafety; for not being able to riſe high enough in diſtillation to cool themſelves, they would break the receiver to pieces by coming hot into it; and hence great damage has been ſuſtained: but by placing the compound retort horizontal, oil of vitriol, *Aqua fortis*, &c. are readily diſtilled to advantage.

*Alembic.* 5. An *alembic* is an inſtrument of this nature; being no more than a matras fitted with a roundiſh head, perforated in a ſloping ſtem, or tube for the condenſed vapours to paſs through, which they do in the form of a liquor, into the receiver. *Fig. 5.* This inſtrument was known to *Dioſcorides*, who ſays, that cinnabar may be raiſed εἰς ἄμβικα; whence comes the word *alembic*, by prefixing the *Arabic al* thereto. And hence is readily underſtood the ſtructure and uſe of the copper alembic, as well as of the cold-ſtill, which nearly reſembles the glaſs-alembic; its head being made of pewter, and its bottom of copper, but lower and wider than the matras. *Fig. 6 and 7.*

*Fig. 8.* 6. A *pelican* is a ſhort and eaſy combination of all the juſt-mentioned veſſels and inſtruments; being a *cucurbit* joined to a fixed, blind-head, in the nature of an alembic, which again communicates with the body by two hollow handles riſing out of the oppoſite ſides; whereby diſtillation and cohobation are both carried on at the ſame time; the liquor that aſcended in vapour being condenſed by the head, and afterwards returned upon the matter below, without opening the veſſel, which has only one orifice at top to receive the ſubjects of the operation. This contrivance is greatly eſteemed and applauded by the chemiſts, and has been much uſed by the adept in the preparation of their ſtone; but it comes dear, and has this inconvenience beſides, that if it be not every where exactly cloſed, all the matter it ought to include, eſcapes; and yet if it be firmly ſhut up, it is apt to break by too great a heat; whilſt a ſmall one will not prove ſufficient to raiſe the matter. For this reaſon I rarely make uſe of a *pelican*; *Fig. 9.* but in its ſtead chuſe two *matraſſes*, with very long, ſlender necks, and invert the mouth of one into that of the other, and in the lower put the matter I would diſtil or circulate. This compound veſſel, or circulating-glaſs, I place in a furnace fit for the purpoſe, and lute the juncture, having firſt well heated the glaſſes to rarify and exclude the air contained within them. After this, I ſuffer the matter to boil, without any danger of breaking the glaſſes, which would now happen if they were thus joined together in the cold. Thus, for example, if I would reduce mercury to a red powder, I put a pound thereof into an egg-vial, with a long ſtem, and invert another therein; then expoſing them to a proper heat, that both the glaſſes may grow warm, I cloſe the juncture, and commit it to the fire; which will now drive up the mercury to the top of the lower matras, and let

*PLATE. I.* CHEMICAL VESSELS. *To face p. 376*

it fall back again, till the work is finiſhed. This veſſel was known above a thouſand years ago; and had the name of *pelican* given it from its action, which reſembles that reported of the bird famous for nouriſhing its young with its own blood.

The nature of the bodies to be worked on, their degree of volatility and fixedneſs, and the parts deſigned to be obtained therefrom, or the union and mixture to be made thereof, will direct to the proper choice, application, and poſition of the ſeveral veſſels we have here deſcribed. The more volatile the matter to be diſtilled, or the more open and ſubtile the body from whence any thing is to be drawn, the higher ſhould the receiver be placed, and the narrower its neck, and that of the cucurbit or matras. Thus, for example, if you would ſeparate pure ſpirit of wine from the water wherewith it may happen to be mixed, make choice of a very tall veſſel; and, with a proper degree of fire, nothing but the ſpirit will aſcend into the receiver. But where the ſubject to be diſtilled off, is leſs volatile and ſubtile than that ſpirit, the veſſel ſhould neither be ſo tall, nor ſo narrow at the top *. *Their manner of uſe.*

## *Of* FURNACES.

FUrnaces *are thoſe inſtruments, or machines, employed in the practice of chemiſtry, whereby the fire requiſite to the operations of that art, is kept together, moderated, and determined upon the ſubject to be changed.* Every furnace, therefore, muſt be capable of containing fire, of reſtraining or keeping it from ſpending it ſelf too faſt, and of guiding and directing it, as the end whereto it was deſigned ſhall require. Hence we learn that furnaces have a double office to perform, as regarding not only the fire, but alſo the ſubject to be changed thereby. With reſpect to the former, they muſt have a current for the air, a chimney, a fire-place or grate, and a hole for the aſhes; and with regard to the latter, a place for the chemical veſſels to ſtand in. *Furnaces defined.*

Thoſe furnaces are the beſt which are moſt ſimple and eaſy in their conſtruction, produce the effects required from them with the leaſt expence and trouble, afford a conſtant and equable degree of heat, and allow their fire to be recruited, managed, and directed with all deſirable convenience. *Which the beſt.*

A furnace ſhould perform its office with little expence; that is, it ſhould entirely conſume the fewel deſigned to feed the fire, and let the whole force thereof be ſpent upon the ſubject to be changed; without any part being loſt, or ſuffered to go aſide. It ſhould afford a conſtant

* To theſe might be added numberleſs other kinds of veſſels, differently contrived to anſwer the ſame or different ends; but ſince a courſe of chemiſtry may very well be carried on with theſe few ſimple ones, and the aſſiſtance of *teſts* and *crucibles*, it is needleſs here to deſcribe any more: the commodious preparation of vendible commodities in large quantities, and to the greateſt profit; being foreign conſiderations, regarding the trade of chemiſtry rather than the art.

degree

degree of heat, that the fewel may have its effect without loss of time, and not at every turn require the presence and assistance of the artist. The heat should also be equable, because every degree of fire has different effects upon the same subject. So that when a chemist is requested to change a given body into one of another species, with an assigned degree of fire, if he should happen to vary that degree, he would never obtain the production required. This ought to be heedfully attended to in chemical operations; for if the fire should once be lowered when it ought to have been raised, or kept up to the same degree, 'tis in vain to expect a perfect production from the operation; how much soever you afterwards increase, or carefully regulate the fire.

The perfection, therefore, of furnaces consists in being easily made, and of cheap materials, so as to suffer the fire to act equably on the subject in any assigned direction and degree; which will depend upon the quantity of fewel made use of, its nature, and the current of the air thro' the same. The fire that is every way enclosed and guarded from the air, or every way equally exposed thereto, will soon be totally extinguished; but the more it is determined and confined to the object, the greater force it will exert thereon, and *vice versâ*. Thus when the rays of the sun are collected by a burning concave, and all are directed to one point, called the *focus*, their force is exceeding great, and productive of wonderful changes in bodies. And the like is practicable in furnaces; the best whereof are reckoned those which afford the greatest or most suitable degree of heat, with the least quantity of fewel. There are various kinds of chemical furnaces, both portable and fixed, described by different authors; but the most commodious, and generally useful, or those proper for our succeeding course, are the following.

*Fig. 1. Plate II. The athanor.*

1. The first which occurs, as affording the most temperate and equable warmth, is the *athanor*, otherwise called the tower-furnace, the philosophical furnace, and *furnus pigri Henrici*; the heat whereof may be made not to exceed that of the human body in a healthy state.

Its structure may be this: Erect a concave parallelopipid, as A B G, of any proper material able to endure the fire; let an iron-grate be placed therein at F E, and above this let there be a hole of any size at D K, thro' which the air may enter so as to direct the action of the fire between the two sides F, E.

Suppose, also, a plate of iron, in this case usually called a register, fitted into the hole at D K, which by admitting or excluding the air will serve to regulate the fire, or determine the degree thereof.

Now when the vent A B is stopt with a dome or cover of iron, the heat of the fire upon the grate, ascending parallel to the sides of the furnace, and being stopped by the cover A B, will be reflected, and kept in; so that we may easily measure the degree of heat by a thermometer; and according as it proves too great or too small, the hole at D K may be the more closed up or opened by means of the register. And

thus

thus the heat of this furnace may be meaſured, intended, and remitted at pleaſure; for the more air is let in upon the burning fewel, by withdrawing the regiſter, the greater will be the heat, and *vice verſâ*. And by this contrivance, 'tis poſſible to keep up an equable and moderate degree of heat, for the ſpace of ſeveral weeks; the fire-place CDEF being at firſt filled with fewel from FE to CD, will conſume gradually, letting fall the aſhes into the hole G. DHIK is the place of the ſand-heat, and LHMN is the chimney. This furnace is of uſe in all caſes where we require one determinate, moderate, and equable heat; tho I have diſtilled ſpirit of hartſhorn by means thereof, and ſometimes, on other occaſions, heated the iron-cover, or dome, even red-hot.

2. I have two kinds of *digeſting-furnace*, both of my own contrivance; the one made of potters clay, the other of wood. The firſt is ſomewhat roundiſh or cylindrical; and in its fire-place receives a ſquare tile, made of the ſame kind of clay, whereon I place a glowing-coal, firſt burnt till it yields no more ſmoke, and afterwards cover it with clean turf-aſhes, ſifted lightly thereon, without preſſing them down, to the thickneſs of an inch. Then ſhutting the fire-place with its door, I can by this means preſerve an equable heat, without diminution, for ſeveral hours, or till the glowing coal is totally conſumed; after which a freſh one may be ſubſtituted. The veſſel containing the ſubject, being placed at the top, is to be covered with a dome, having a round hole in the middle to give paſſage to the neck of the veſſel, ſo as exactly to fill up this upper aperture of the furnace, and lie with its neck bedded in a cavity made on purpoſe to receive it. Things being in this poſture, the fire may thus be kept equable at little charge, without any need of a chimney, and without ſmoke or other inconvenience. This furnace is principally uſeful when any digeſtion or diſtillation is to be performed with a gentle heat, that ought not to be remitted. And thus I have ſometimes continued an operation of this kind for nine months together. *Digeſting-furnace.* *Fig.* 2.

3. My *wooden digeſting-furnace*, is made in the form of a parallelopipid. Its ſtructure is now generally known, and much the ſame with the foregoing. 'Tis highly uſeful on many occaſions, and labours under but one inconvenience; and that is, being made of wood, 'tis apt to crack with the heat. The fire in it is maintained with very little expence, and may long be kept in an uniform degree, without any conſiderable variation, ſo as to make plants grow, &c. See *Fig.* 2.

4. The *ſimple furnace* for the *cold-ſtill*, made uſe of in drawing the odoriferous, or exhalable waters of recent vegetables, is made in brick-work to receive a ſhallow, copper body, fitted with a large, conical, pewter head, to condenſe the vapours raiſed by a gentle heat, and turn them into liquor, to be tranſmitted into the receiving-veſſel thro' a roſtrum fixed to the ſide, near the bottom of the head. By means of this ind of furnace, we come to know what it is which *Cold ſtill.* See *Fig.* 6, *Plate* I.

ſpontaneouſly

ſpontaneouſly exhales from vegetables by the warmth of the ſummer's ſun, *&c.*

*Hot-ſtill, or copper-alembic.*

*See Fig. 7. Plate I.*

5. The *common furnace* for diſtilling all kinds of waters, from vegetable or animal ſubſtances, is of admirable uſe; and is made to receive a copper body, placed in the midſt of brick-work, after the manner of a copper for brewing, with its metalline head; the beak whereof is joined to a ſpiral tube, or worm of lead or pewter, that runs its winding courſe thro' a large veſſel of cold-water, called the refrigeratory, ſo that by means of a long deſcent thro' ſuch a veſſel, the diſtilled liquor is made to come off cool, tho the matter in the copper-body ſhould boil ever ſo faſt; whence it does not endanger the breaking of the glaſs-veſſels, which here perform the office of receivers, as it would do, were it to come over boiling hot into them. This furnace greatly ſhortens the work of diſtillation, and renders that performable in a few hours, which otherwiſe could not be effected in the ſpace of many days. But when the matter to be diſtilled is volatile, and requires only a ſmall degree of heat to raiſe it, there is no occaſion for the worm and refrigeratory; but the liquor may immediately be received in a proper veſſel, as it falls from the *roſtrum* of the ſtill-head, or from a tube that paſſes without winding thro' the refrigeratory.

*Balneum Mariæ.*

*Fig. 3.*

6. The *bath-furnace*, *balneum maris*, or *balneum Mariæ*, is a copper body of water, receiving another fitted with its head or alembic; and this compound alembic is to be ſo placed, that the fire applied may make the water boil; which being conſtantly kept in that ſtate, will afford the ſame uniform degree of heat, tho the fire be great or ſmall. This furnace is of uſe in diſtilling all kinds of ſubtile or volatile ſpirits and waters, as thoſe of roſes, *&c.* without danger of ſpoiling their flavour by burning them to the ſtill; as alſo in rectifying ſpirit of wine, *&c.*

*Sand-furnace.*

*Fig. 4.*

7. The *ſand-furnace* is deſigned to convey heat to the veſſel by the interpoſition of ſand, which, being contained in an iron-pot, receives the action of the fire below. This is uſed where we require a greater degree of heat than can be given by boiling water; and may be raiſed ſo high as to melt the veſſel, or make it red-hot *.

*Wind-furnace.*

*Fig. 5 and 6.*

8. The *wind-furnace*, *melting-furnace*, *reverberating-furnace*, or *aſſaying-furnace*, is deſigned to give the moſt violent degree of heat, which may beſt be effected by making it of an elliptic figure; provided the furnace be ſo contrived that the grate ſtands in one focus, and the veſſel containing the ſubject in the other: for as it is the nature of fire to go off every way in ſtrait lines from the centre to the circumference; 'tis manifeſt from mathematics, that all the rays which go from the lower focus of the ellipſis to the circumference, will from thence be reflected to the upper; and conſequently, if the fire be placed in one focus of the ellipſis it will produce a violent degree of heat in the other. And

* The filings of iron are ſometimes uſed inſtead of ſand, for this purpoſe, as conceiving a much greater degree of heat than that.

after

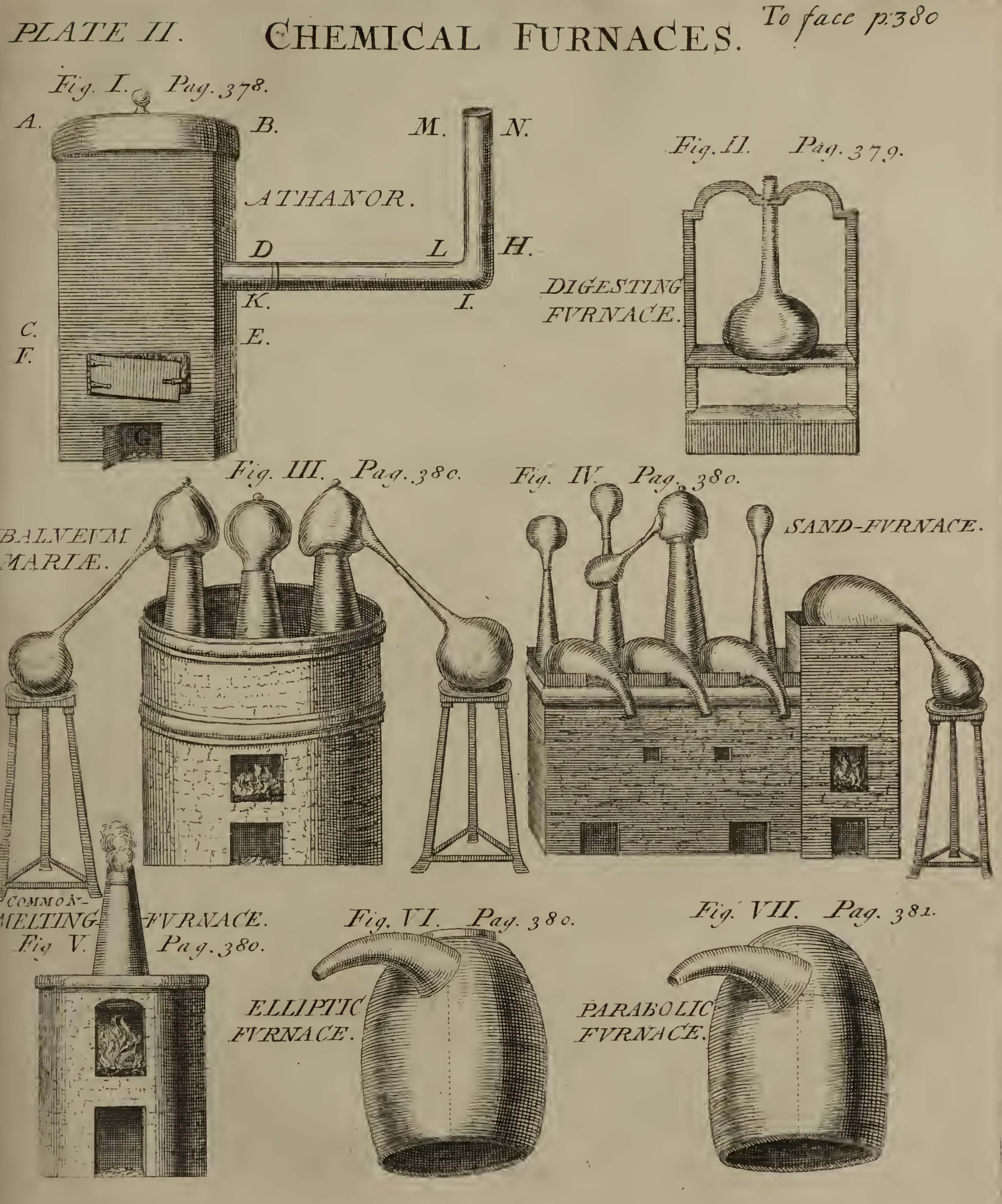
PLATE II.
CHEMICAL FURNACES.
To face p:380
Fig. I. Pag. 378.
A.
B.
M.
N.
ATHANOR.
D
L
H.
K.
I.
C.
F.
E.
G
Fig. II. Pag. 379.
DIGESTING
FVRNACE.
Fig. III. Pag. 380.
BALNEVM
MARIÆ.
Fig. IV. Pag. 380.
SAND-FVRNACE.
COMMON-
MELTING-FVRNACE.
Fig V. Pag. 380.
Fig. VI. Pag. 380.
ELLIPTIC
FVRNACE.
Fig. VII. Pag. 381.
PARABOLIC
FVRNACE.

after the ſame manner a furnace may be erected for diſtilling acid ſpirits, or the like, with a naked fire and earthen retorts.

9. But of all the various kinds of furnaces invented by chemiſts, the parabolic are thoſe which throw the greateſt heat upon the matter to be changed, in proportion to the quantity of fewel employed. Theſe are built in ſuch a manner, as that the plane of the grate may paſs thro' the extremity of the *abſciſſa*, and be at the ſame time perpendicular thereto; the veſſel containing the ſubject, being placed in the focus: for 'tis mathematically demonſtrable, that all the rays, which here tend perpendicularly upwards from the plane of the grate, after they once arrive at the ſurface of the parabola, are thence reflected back to the focus; where they produce the greateſt poſſible degree of heat, in proportion to the quantity of fewel; which is not ſo true of the furnaces of any other figure. *Parabolic furnace.* *Fig. 7.*

But a knowledge of all the various kinds of furnaces, is better acquired by inſpection, and being converſant in the laboratories of chemiſts, than by any deſcription we can give of them *: tho what is here delivered upon the ſubject, will ſuffice for our purpoſe, and furniſh us with all the furnaces we need hereafter employ in our courſe of operations.

## LUTES.

BY *the word* lute, *chemiſts underſtand ſuch a matter, as being ſpread upon the junctures of communicating veſſels, will exclude the external, and keep in the internal air.* Such a matter is requiſite to the due performance of diſtillation, in which the veſſels concerned are ſo ſtrictly to be joined together, as that no part of the contained ſubject may perſpire, or be loſt. The lute, or cement, commonly uſed in the diſtillation of inflammable, alkaline ſpirits, waters and other liquors, which are not of an acid nature, is made of linſeed meal, well cleared of its oil by expreſſion, and mixed up into a paſte with as little water as will ſuffice for that purpoſe. This is an admirable kind of lute; for being ſpread upon the junctures of veſſels, it preſently acquires the hardneſs of a ſtone; and yet upon occaſion, may be readily ſhaved off again. But in the diſtillation of acid ſpirits, we muſt have recourſe to a lute of a different kind, called by the name of *lutum ſapientiæ*, or the luting of *Lutes defined.* *The common lute.* *The philoſophical lute.*

* The buſineſs of furnaces, tho it has been treated of by almoſt all chemical authors, ſeems capable of great improvement. A knowledge of mathematics, and of the properties of the air and fire, will enable us to conſtruct them to more advantage than hath hitherto been practiſed among chemiſts; who ſeldom happen to be maſters of more knowledge than they get out of the fire. Thoſe here deſcribed will ſerve very well for the common purpoſes of chemiſtry, or the following courſe of experiments; but the larger work requires a ſuitable contrivance, to leſſen the expence, and yet perform the operation in as great perfection as if it were done in miniature: but this conſideration belongs to the trader more than the artiſt.

the philosophers; the common sort being not all fit for this purpose. The philosophical lute is composed of colcothar, or the *caput mortuum* of vitriol, boiled in several parcels of fresh water, till the decoction at length becomes insipid, or retains no saline part of the colcothar; which being now reduced to a perfectly dry powder, and kept a-part, may be mixt occasionally with an equal quantity of quick-lime, and a small proportion of the white of an egg, first well beat with a spoon, so as to make the whole, with great expedition, into a paste, to be used the moment it is formed; otherwise it will grow too hard and unfit for use. This lute being thus rightly prepared, and seasonably applied, will by heat become as hard as glass it self, and suffer no liquor to escape it. But in case it should crack, as it sometimes will, new must be applied, to fill up the interstices. But there is a much readier way, which I sometimes use, of making a paste for this purpose; which consists only in taking a proper quantity of potters-clay, and working it up with sand, between the fingers, till it will no longer stick to them; and this with as small a quantity of water as possible. Glasses being luted with such a composition, which is afterwards to be dried upon them, and the operation repeated or amended, if any cracks should happen in it, will, in some cases, be kept sufficiently close for the purpose above-mentioned. Or a still shorter and easier way may be to soak a hog's bladder in water till it begins to corrupt, and acquire a nauseous scent; which being afterwards applied to the junctures of glass-vessels, and gently dried, will stick almost as fast thereto as if it self were a part of the glass.

Mr. *Boyle* supplies us with an excellent cement to strengthen and hold crack'd glasses together, so as to fit them for farther use. This cement he made of the fine shavings of old fat cheese, and an equal quantity of quick-lime, worked together with a little water, and spread, like a plaister, upon linen, to be applied along the crack *. But the cheese and the quick-lime are to be kept separate, and not to be mixed till the cement is wanted; and then, too, the mixture must be made with great expedition, or else it will grow hard and unfit for the office.

*Lute for coating of retorts.* When cracks happen in the furnaces, they are to be filled up with a lute or cement made of sifted ashes, and a small quantity of water, well mixed and worked together; for a paste thus prepared, will admirably close these gapings, and at the same time endure a most violent heat. There are several occasions in chemistry which require the use of glass-vessels in

* There is another cement made use of by some chemists of *London*, to answer the same end, consisting of sifted wood-ashes, beat up to a due consistence with the white of eggs, and a little gum-water. The same service may, in a more excellent manner, be had as well for cracked glasses as broken china, or the like, from what the painters call drying oil, or a mixture of linseed oil and ceruse, made, by insolation or decoction, into a perfectly white balsam, and afterwards ground upon a marble with fresh ceruse, till the whole is perfectly fine, and become of the consistence of an unguent. This dries slow indeed, but is very effectual.

in a naked fire, whereby they would be made to flow, unless defended from the violence of its action; as they may be by means of a cement, already mentioned, made with potters earth and sand. Thus in the separation of quick-silver from other metals, wherewith it is amalgamated; in the recovering of the sulphur from cinnabar or æthiops mineral, in the preparation of *Ens veneris*; or, in the like cases, we are obliged to give our retorts a case to keep them from melting in the fire. This case for their defence is made by mixing such a quantity of common sand with potters clay, as will suffice to take off its unctuosity, and prevent its sticking to the fingers; then with a small quantity of water, it may be reduced to a paste, which being spread to the thickness of half an inch, or less, upon the whole external surface of a retort, and set in a warmish place to dry gently, it will become hard, and enable the glass to endure a strong naked fire. But if, in drying, the paste happens to crack, it must be mended with some of the same, as before, and dried rather more gently. And this method of defending retorts, is, among chemists, called by the name of *coating*.

These are all the kinds of cements absolutely necessary in the practice of our art: and thus, at length, we have distinctly gone thro' the whole *apparatus* or *theory* of chemistry, and are now prepared to proceed to the practice.

## *End of the* THEORY.

Part II.

# PART III.

## THE PRACTICE OF CHEMISTRY,

*Exhibiting a chain of processes, perform'd, by the agents mentioned in the second part, on the several subjects of the three kingdoms,* vegetable, animal, *and* fossil; *in a geometrical method, proceeding, step by step, from the most simple and easy operations, to the most complicated.*

### INTRODUCTION.

WE are now prepared to enter upon the third and last part of our undertaking; the performance of those operations whereby a chemist directs his inquiries into natural bodies; and from whence he forms his doctrine about them.

Chemical operations, otherwise called processes, are no more than particular methods of changing the bodies described in the foregoing theory, by means of the instruments there enumerated, so as to render the changes they suffer observable to the senses. Or, more particularly, a chemical operation is such an application of

fire to any part of the *materia chemica*, as may effect a change therein, yet leave it capable of being compared with what it was before.

The principal reaſon why chemiſtry has been condemn'd and ſlighted by ſome men of eminence in the world, is the bad order hitherto obſerved in delivering theſe proceſſes or operations. For, chemiſts have given us the hiſtory of their experiments in ſuch a diffuſive, tumultuary and miſcellaneous manner, as renders them exceſſively diſagreeable, tedious and uninſtructive. When they treat different ſubjects, of the ſame claſs, in the ſame or a ſimilar manner, they would have their readers believe they give them different proceſſes; but, in reality, the caſe is otherwiſe: and were it not, yet to a learner it would be no more than an idle and uſeleſs repetition of the ſame thing. In order to inſtruct a perſon how to diſtil the water, or gain the eſſential oil, of any plant whatſoever, he need only be taught the method of doing it in roſemary, for inſtance, and not in a thouſand different herbs; which would be multiplying examples to no manner of purpoſe; becauſe all other vegetables are to be managed in the ſame manner, with the ſame inſtruments, to the ſame end. We, therefore, purpoſe to retrench this redundancy of the chemical writers, and only give the neceſſary, the uſeful and inſtructive part of this valuable ſcience, in a ſelect number of general proceſſes, ranged in ſtrict geometrical order. Beginning with ſuch as are moſt ſimple and eaſy, we ſhall proceed, ſtep by ſtep, to the more difficult, complicated, and laborious; ſo that the firſt will lead to the ſecond, the ſecond to the third, and all have a mutual connexion with, or dependance upon, one another: whence the whole number, taken together, will make an entire chain, or ſyſtem, of chemical operations; every one whereof is a canon, example, or ſtandard-rule for performing all others of the ſame kind. The advantages of ſuch a method are very conſiderable; for it will never ſuffer us to omit, in the foregoing, any particulars neceſſary to the ſubſequent proceſſes; nor oblige us to repeat any ſingle operation: ſo that by this means, tho' the objects of chemiſtry are numberleſs in every claſs, and the changes to be wrought upon them infinite, we ſhall clearly and ſatisfactorily exhibit the whole art, in one collected, uniform view; the proceſſes made choice of being all of them general, as well as particular; and together ſhewing the manner of performing all ſorts of chemical operations; being themſelves the elements of the art.

The general manner in which ſuch a courſe of proceſſes ought to be conducted, is, (1.) Strictly to ſurvey, and examine every ſubject, with all our ſenſes, before 'tis committed to the operation; and, as much as poſſible, to keep to the ſame ſubject in different proceſſes. For if we ſhould draw our oil from roſemary, our water from mint, our ſalt from lavender, and ſo make uſe of a new plant for every operation, we ſhould run into great confuſion; and never learn all the ſubſtances obtainable from any one vegetable. (2.) To deſcribe the operation, and the manner wherein it is to be conducted. (3.) To give

give an account of the effects that are produced. (4.) To examine the remainder, or what is left behind after the operation is finiſhed; and compare it with what the ſubject was originally. (5.) So far as is neceſſary, to deſcribe the apparatus, or inſtruments, made uſe of. (6.) To ſubjoin what ariſes of uſe, or may be deduced, from every experiment, by way of corollary, with regard to natural philoſophy. (7.) And, laſtly, with all poſſible exactneſs and fidelity, to point out the medicinal virtues of ſuch particular productions of the art, as, by competent experience, have been found to deſerve it; to ſhew how they are applicable in the practice of phyſic; to what diſeaſes they are particularly ſuited; and in what doſes they ought to be given. But we are not to expect that every chemical operation muſt needs preſent us with ſome excellent medicine or other, as the major part of chemiſts have fondly imagin'd; for this art is ſo far from being a ſlave to the narrow views of pharmacy only, that it deſerves to be united with many of the nobler ſciences; and, in particular, with natural philoſophy, of which 'tis, without diſpute, the principal branch.

# SECT. I.

## *Exhibiting a Courſe of* PROCESSES *upon* VEGETABLES; *the moſt ſimple and reſoluble of Organical Bodies.*

## The Fundamentals of the ART;

### *Shewing in what manner the Chemical Analyſis of Bodies is to be undertaken.*

*A vegetable ſubject to be choſe for the firſt proceſs in chemiſtry.*

1. THE order we have preſcribed ourſelves requires us to begin our operations with a ſubject, which, of all others, is at once the moſt ſimple, eaſieſt reſolvable, or whoſe parts are ſeparable by the ſmalleſt force, and ſuch as will ſerve for a baſis to the experiments that are to follow: it can, therefore, be no other than one taken from the vegetable kingdom; for, bodies of this claſs are reſolved, analyſed, or chemically treated with more eaſe than animal or foſſil ſubſtances. Vegetables, alſo, are of a more ſimple ſtructure than animals; whoſe bodies being compoſed of the former, makes the knowledge of vegetable ſubjects

jects requisite to the understanding of the animal: whence our inquiries into their nature ought to begin with vegetables. 'Twould be highly improper here to set out with fossils; for, tho' these are more simple, or inorganical, than the bodies of animals and vegetables; yet they want several other qualifications: in particular, they require too great a violence of fire to work upon them; and suffer too great a change in their resolution, to be fit for this purpose. At first setting out we require only a bare separation of the parts, and not a perfect transmutation of the subject. Gold is a very simple body, indeed, but exceeding difficult to analyse. On the contrary, recent vegetables contain a water, which evaporates with a very gentle heat, and is therefore easily obtainable; whence these are much properer subjects than fossils, to be first treated in a course of chemistry; and ought likewise, on account of their simplicity, as well as the share they have in composing the bodies of animals, to precede them. But the plant made choice of for the subject of our first operation, should be fresh gathered, and in its perfection; otherwise it would not afford the volatile part we ought to gain from it. By making choice of such a subject to begin with, we shall obtain a method of examining into the composition of all bodies, by separating them into the parts, or simple substances, whereof they were originally composed; or of taking bodies to pieces after the same manner as they were naturally put together. To know what the body of an animal is, we ought first to know what it feeds on; and, if we would know the composition of human blood, we ought first to be satisfied as to the food made use of by mankind: and the food of all animals consisting ultimately of vegetable substances, 'tis evident we should begin our processes with these.

*What instrument is to be made use of in it.*

2. The instrument of the first operation, or the thing which the artist directs and applies to give the motion made use of in it, should be (1.) most pure and simple, or such as will impart but little of itself to the subject. (2.) It should be universal, or such as may conspire in every future operation. (3.) It should introduce but very little change in the subject. (4.) And, lastly, it should leave the separable parts distinct, or blend them but little together. To all which characters there is nothing so well entitled as a clear, soft, equable fire. Fire is the general instrument of chemistry; and therefore a small degree of it will very well coincide, or consist with the greater, required in other operations. And a gentle fire will not much confound, but only separate the parts of the subject. Thus, if quantities of spirit of wine, water, oil and salt were mixed together, and the whole exposed to a soft heat, the spirit would rise first, the water next, the oil third, and the salt last; provided the heat were strong enough to carry it up: whereas, if a vehement fire had been at first employ'd, the several bodies would have all risen confusedly together, and no instruction have been reap'd from the process. But, a clear, soft, equable heat, applied to a fresh-gathered plant, or volatile vegetable subject, will produce distinct and

clear

clear effects; the uses whereof are very extensive, and serve to instruct us in the nature of all other chemical operations.

*What are to be the properties of the first process.* 3. Again, our first process should be, (1.) independent and absolute; or require no other to precede it. (2.) It should be performable with the greatest ease. (3.) It should be exceeding simple, or the least complicated of any known operation; and consequently must require the fewest agents, the smallest action, and the least apparatus. (4.) It ought, as was said of the instrument, barely to separate the parts of the subject; and by no means to alter, confound or transmute them; but leave them in such a state, that farther experiments may either be made therewith, or when joined together again, they may nearly exhibit the thing as it was at first. This is the true nature of separation, whose office it is to preserve the genuine parts of a compound distinct, without alteration. Motion is the universal cause of change in bodies, except in those that are elementary; and, according to the degree thereof, the greater or less alteration it occasions. 'Tis possible, by motion, or fire, to change a body so, that it could no longer be known for the same. Thus, rosemary could not be known for such, if it were reduced to ashes: whence 'tis very ill concerted of those who make calcination the first operation in chemistry.

*The advantages it shou'd afford.* The advantages to be gained from a process having the qualifications above-mentioned, are, (1.) A knowledge of the separated parts, or ingredients of the subject; which being barely separated, not changed, there can be no doubt that they before existed in it. (2.) A knowledge of the remains, or the parts left behind after the operation is finished; which could not be had if the subject were greatly changed: for if wormwood should once be reduced to ashes, we could not distinguish them from those of any other plant. But when a process is carried on by mere exhalation, and the subject loses nothing of its form, only appears somewhat dry and shrivel'd, no body can question whether what was thus obtained from it once made a part of the subject. (3.) The power of examining the remainder by new experiments. For a mild and gentle operation will only take away the parts that were easily separable, and leave the others entire. Thus, after the volatile, or aqueous part is drawn away from a plant, we shall find the remainder dry, perhaps, and shrivel'd; but still possessed of its former figure, and capable of farther examination. Which gentle way of proceeding is admirably suited to discover the composition of bodies: but to expect the same advantages after a violent operation, were to look for snow in the dog-days. (4.) And, lastly, we shall hence gain a clear and distinct idea of the instrument employ'd, and the action it performs. All which particulars will be fully illustrated in the first process it self.

4. When, therefore, the most simple action of the most simple instrument is applied, or determined, to a most simple vegetable subject

ject, as above described, the change produced thereby will be small and simple, yet discernible, clear and distinct. But the nature and effects of this operation are to be well considered, before we proceed any farther; for no other process can possibly be understood without the assistance of this. 'Tis as requisite to the knowledge of all the succeeding operations, as the knowledge of exhaltion is to that of decoction. That we may therefore come fully prepared to understand this fundamental operation, we will here inculcate, or repeat, so much of the natural history of vegetables, as seems proper for our purpose.

5. Vegetables consist of two different parts, solids and fluids. The solids, being either vessels or receptacles, are, (1.) The absorbing vessels, or those which drink in nutriment from the earth, or air, or something mix'd with either, are seated all over the external surface of every plant; in the root, leaves, bark and flowers: and tho' their orifices are so small, as scarce to be discerned with a microscope; yet the nutrimental juice, which feeds the vegetable, every where finds entrance thereat; and is from thence conveyed to the internal parts. These vessels seem to perform that office in vegetables, which the lacteals, and those of the skin, do in animals. They appear lodged in greatest plenty about the root; but that they also exist in other parts is manifest from hence, that if a lopped willow, for instance, be, without its root, set in a proper soil, it will again shoot, bear leaves, and increase in bulk. The aloes-plant of *America* will do the same, when hung in the air with its root wrapped up in paper. And if the branch of a tree be stripped of its twigs, and set with its top downwards in the earth, it will grow in this inverted manner; so that what was before the apex, now becomes the root; whilst all the shoots strike downwards to the ground. (2.) The moving vessels, or those which carry and propel the fluids, are composed of elastic fibres, which dilate with heat, and contract with cold; by which means the liquors are circulated through them. 'Tis their office to carry away, and distribute the juice drank in by the vessels of the former kind, through the body of the plant, of which they may properly be called the circulating vessels; for in these the crude matter, drank in by the absorbing vessels, is altered, digested, prepared, and at last assimilated into the nature of the plant itself. These circulating vessels seem to be a combination of the arteries, veins and lymphatics of the plant; being placed in the trunk or stock of the tree, and the woody parts thereof, which differ greatly from the flowers, the leaves and fruit: they are also endued with valves to prevent the circulating liquors from falling back, or returning in them. (3.) The air-vessels seem to be distributed every where about the plant, to the end that, by forming into bladders, and contracting and dilating themselves, according as the heat of the sun, and the cold of the night, reciprocally expand or condense the air within them, they may squeeze the circulating vessels in their neighbourhood, and so help to propel their fluids upwards; otherwise they could hardly rise to so great a height as in some trees we see they do: for the sun's heat, by

*The vessels of vegetables.*

rarify-

rarifying the air at the top, more than it does at the bottom of ſuch trees, could never ſuffer the lower air to preſs the vegetable fluids above thirty-ſix feet high; whereas we daily obſerve trees riſe much higher than that. There ſeems, therefore, to be occaſion for this diurnal expanſion, and nocturnal contraction, acting like the ſyſtole and diaſtole of the heart, to throw up the alimental fluids of vegetables; as alſo for valves to hinder their returning back the ſame way. And thus theſe fluids may move briskly in the day-time, and but languidly by night; during which, they therefore appear to reſt or repoſe themſelves. And this ſeems to be requiſite for them; ſince we obſerve that plants never thrive ſo kindly in the conſtant heat of a green-houſe, as when they enjoy the open air. (4.) The ſecretory veſſels ſeparate the proper juice of the plant from all the reſt of the fluid matter brought into it. Thus, the aloes-plant, from one and the ſame liquor, ſeparates honey in its flowers, and an intolerably bitter juice in its leaves. Theſe veſſels are found in the bark, buds, leaves, flowers, and parts the moſt remote from the roots. It appears to be their office to ſeparate, and change the general fluid of every plant into ſubſtances of different natures; as into oil, ſalt, and water. Tho' the aloes-plant and ſugar-cane were to grow near one another, they would ſeparate, and afford very different juices: which ſeems owing to nothing but a difference in the ſtructure of their ſecreting veſſels. (5.) The excretory veſſels breathe out the ſuperfluous, or excrementitious matter, which, being detained, might prove injurious to the plant. Theſe veſſels are placed every where in the ſurface, or bark of the vegetable. Thus, we cannot doubt that there are emunctory veſſels in roſemary, for inſtance, which is continually diffuſing an odorous atmoſphere around it. And thus, in the ſummer ſeaſon, when the air is greatly heated, all aromatic and odoriferous plants come to exhale vaſt quantities of their fine, ſpirituous and volatile parts.

*Their receptacles.*

6. The receptacles, or receiving veſſels of vegetables, which contain the ſecreted humors, are little cells, wherein is depoſited and lodged the oil, or unctuous part; as the fat of the bodies of men adheres to its cells: for plants have their *panniculum adipoſum*, or covering of fat, as well as animals; and over this a bark or cruſt, which anſwers to the skin in man. And ſince, in general, the moſt fragrant part of vegetables reſides in their flowers, and not their leaves; it is evident there are receptacles placed in the former, to receive and preſerve their odoriferous matter.

Thus we ſee, that the ſolid veſſels of vegetables are either ſuch as drink in moiſture, ſuch as have a degree of motion, or form themſelves into air-bladders, ſuch as perform the office of ſtrainers, ſuch as diſcharge and throw off the excrementitious parts into the air, and ſuch as lodge ſome particular ſecreted juice, or humor.

*Their various juices.*

7. All theſe different kinds of veſſels appear to contain different ſorts of fluids, which are either aqueous, ſaline, oily, ſpirituous, gummy, balſamic,

mic, or reſinous; all which may be artificially obtained from vegetables. The aqueous fluids are generally found in the abſorbing veſſels, but mixed with a large proportion of ſalt, which, tho' always ſoluble in water, otherwiſe appears of very different natures in different plants; being ſometimes fix'd, as it were, and ſometimes volatile; as particularly in ſcurvy-graſs and horſe-radiſh. Even the dryeſt vegetables hold a proportion of water. Thus, roſemary, which appears to contain but very little moiſture, affords a conſiderable quantity by diſtillation. But all vegetables abound moſt with ſalt and water, in the ſpring of the year. The oily part, that is, the part which grows fluid at the fire, proves inflammable, and will not unite with water, is, always found in the receptacles of a plant; but in the greateſt plenty during the autumn: at which ſeaſon, the timber deſigned for building is, therefore, generally fell'd; as then proving the moſt durable and fit for uſe. But this oil is never to be obtained pure from vegetables; ſome quantity of ſalt, water, earth, or other ſubſtance, being always mixed along with it; which is the reaſon of its turning rancid. The ſpirituous parts, or thoſe which contain the odour and taſte of the plant, are very volatile, will mix with water, and ſometimes burn in the fire; the oil of the vegetable being here greatly attenuated, broke, and ſubtilized. Inflammability, however, is no way requiſite in a ſpirit: thoſe generally called by the name of acid ſpirits, tho' they extinguiſh fire, are as much ſpirits, as highly rectified ſpirit of wine, which is wholly inflammable. Gums are ſuch productions of vegetables, as will mix with water, diſſolve over the fire, and burn away; being tough, viſcous ſubſtances, and containing a large proportion of the oil and ſalt of the plant. Balſams are the native oils of vegetables brought to a thick conſiſtence; but containing a proportion of an acid ſpirit and ſalt. However, they differ greatly from the oils they afford. Thus oil of turpentine is a very different thing from the balſam, or turpentine itſelf. Roſins are ſuch productions of vegetables, as, being hard and dry, prove brittle in the cold, diſſolvable by heat, inflammable and miſcible with oil, but not with water. The weepings or tears of vegetables, or the juices which diſtil from them when wounded, are either aqueous, as in the birch-tree, pitchy, as in the pine-tree, or ſomewhat acid, as in the vine.

8. Theſe liquid parts of vegetables greatly differ from one another, in various reſpects; being, (1.) of different taſtes in different plants, or different parts of the ſame plant. Thus the juice of the aloes-plant is exceeding bitter; whilſt that of the ſugar-cane is ſweet: and this will be the caſe, tho' different plants grow ever ſo near to one another; or draw their nouriſhment from the ſame ſpot of ground. And the like is true of different parts of the ſame plant. Thus in the ſugar-cane, the juice of the pith is ſweet, but that of the bark ſouriſh. The thorny *African* aloes-plant yields a ſaccharine juice in its flower; *The difference between them.*



whilſt

whilſt that of the leaves is bitterer than gall. In general, oil reſides principally in the bark of vegetables, water and ſalt in the wood, and a mixture of fine volatile ſalt and oil, or ſpirit, in the bloſſoms or flowers. It muſt needs, therefore, introduce great confuſion to ſay that a plant is poſſeſſed of any one particular taſte, or virtue; ſince thoſe will vary in the ſeveral parts thereof. But we may eſtabliſh it as an axiom, or general truth, that the nearer any juices of the ſame, or different plants are to the abſorbing veſſels, the more ſimilar they will be to one another; ſo that I make no queſtion, the juices contain'd in the abſorbing veſſels of liqueriſe and coloquintida, or the bitter apple, are nearly of the ſame nature and properties. (2.) Theſe juices differ alſo in point of colour. Thus, in lettice, the ſow-thiſtle, ſuccory, goats-beard, poppy, the ſpurges, &c. the juices that ouze out of them, when broken, are all white and milky. But if from euphorbium, or any ſpecies of the ſpurges, a leaf be broken off, the acrimonious, or biting, milky juice that ouzes out, where the ſeparation was made, being expoſed to the air, becomes black and poiſonous. Such a juice will continue to flow ſpontaneouſly from one of theſe wounded plants, ſo long as no heat, by contracting or blocking up the veſſels, or thickening the juices in them, joins the lips of the wound; by which means it is that the flux comes to be ſtopp'd. But the juices, flowing in the ſame manner, from the ripe aloes-plant, or from celandine, are of a yellow or golden colour; tho' theſe, and all other plants, when bruiſed, afford a green juice by expreſſion; which is the predominant colour of them all. Upon wounding the red beet-root, there ouzes out a very pellucid liquor; but when the ſame root is bruiſed, it affords one that is exceeding red. In moſt poiſonous plants, the juice is firſt white, then yellow, and black at laſt. And thus too in the ſame vegetable, the juice of the fruit is of a different colour from that of the leaves or flowers; as appears in the ſtrawberry, the mulberry, the cherry, &c. (3.) They differ again in point of ſcent. The exhaling vapor, or juice, of the roſe ſmells differently from that of the jaſmin-flower; and that of the violet from that of the carnation. The juice of the leaves of the jaſmin-tree hath ſcarce any ſcent at all; whilſt that which exhales from the flowers is wonderfully fragrant. And every vegetable has a different and peculiar ſmell in its bark, root, leaves, ſtalk and flowers, which diſtinguiſhes it from all other plants. 'Tis obſervable, that the farther the parts are removed from the root, the ſtronger is their ſcent; which alſo holds true of their taſte. But if a plant be bruiſed, or its veſſels broke and confuſedly jumbled together, it no longer retains its ſpecific ſcent. The carnation, and the roſe, whoſe fragrance is ſo delightful, loſe it all, if once they be cruſh'd between the fingers. The lilly is fragrant in its flower, but fetid in every other part. (4.) Laſtly, theſe vegetable juices greatly differ with the climate and ſeaſon of the year. Thus in the ſpring-ſeaſon, before the fruit is ripe, its juice proves rough and acid upon the tongue,

but

but ſoft and ſweet in the ſummer, when 'tis arrived at maturity. Cherries, mulberries, ſtrawberries, barberries, *&c.* are green at the firſt, then white; but afterwards turn red by degrees. All vegetables, during the time they bud, and put out their leaves, ſcarce afford any ſcent at all; but many of them, when they flower, yield a delightful fragrance. And 'tis univerſally true of plants, that their juices in the ſpring are watry and ſaline; but more compact, and better elaborated in the autumn. Thus, likewiſe, moſt plants in the winter-ſeaſon, prove watery, when the froſty weather breaks, and afford neither an agreeable ſcent, nor any volatile oil. The garden-carot, when firſt it ſprouts from the ſeed, appears green in its leaf, and white in its root; but when come to full maturity, the root is red, and the leaf turns yellow. The *Italian* night-ſhade bears poiſonous berries, that vary in their colour with the ſeaſons of the year, and the growth of the plant. The roſe-tree, whilſt it blows, yields no ſcent in any part but the flower: and there are ſome flowers that afford no odour at all, till they come to open; but, are then exceeding fragrant: which is particularly the caſe of jaſmin. Cherry-trees, whilſt in bloom, breathe out a moſt pleaſing fragrance; but their fruit affords no ſcent at all. And the like may be ſaid of many other vegetables, as well with regard to their taſte, as their odour. After the ſame manner, likewiſe, the juices of vegetables vary in their medicinal virtues. The exhalable vapor of damask roſes proves cardiac, or refreſhing; whilſt their expreſs'd juice is purgative. Green fruit is found prejudicial to the body, but very wholeſom, when fully ripen'd: and experience teaches, that all vegetable juices differ with the climate, both in their taſte, ſcent, colour and medicinal virtues. *Helmont*, therefore, might well ſay, "there is as great a difference between a plant and "its juices, as there is between an animal, and the blood that runs in his "veins."

*The moſt noble fragrant and volatile, to be ſeparated in the firſt proceſs.*

9. Among all the different kinds of vegetable juices, above-mention'd, there is one which conſtitutes the moſt noble and fragrant part of the plant; and which having undergone all the neceſſary changes and ſecretions in the ſeveral organs, and felt the requiſite heat and effects of the ſun, is at length, during the ſummer-ſeaſon, gently breathed out from the emunctory veſſels on the ſurface, after the manner of an inſenſible perſpiration; or elſe, as we learn from experience, it is arreſted and detained by ſome other particular parts of the vegetable, and principally the flower. This being a real juice, and by no means any artificial production, but a perfect and elaborate preparation of nature, made to exhale by the mild and gentle action of the ſummer's ſun; we venture to call it the native or preſiding ſpirit of the plant; becauſe it perfectly contains in itſelf the odour and taſte thereof; and widely differs from the ſpirit which the ſame vegetable affords by fermentation. The plants that every way diffuſe ſuch an atmoſphere around them, are principally thoſe of the aromatic kind; which affect

the nostrils and palate in a pleasing and delightful manner. Thus on the coast of *Narbonne*, in *France*, the rosemary, which there grows in very great plenty, diffuses such a fragrant atmosphere around it, that sailors are thereby warn'd of their approach to this place, at the distance of three leagues from the shoar. Possibly there may be a great number of inodorous plants, which, in the same manner, send out their exhalations into the air, tho' our senses take no notice of them; for as animals are always surrounded with their own atmospheres of perspirable matter, which they neither see, nor perceive; so 'tis not unlikely that vegetables have the same, or something analogous thereto. But we properly enough call those plants scentless, which our nostrils give us no information of; tho' it would be rash to assert that they are absolutely inodorus to all animals in the world.

The vegetable juice, just now described, being the most volatile, or easiest separable, of all those afforded by plants; 'tis manifest, from what was before deliver'd, that our first process ought to be so directed, as, if possible, to obtain it. We find this juice is naturally made to fly off by the heat of the summer's sun; tho' in a form invisible, and without causing any great change in the plant. But 'tis the business of chemistry to include objects in proper vessels, so as to render the changes, or effects of the operation visible.

*Rosemary consider'd for the subject of it.*

In order then to obtain this juice, or water, let us make choice of the plant rosemary; because it is an aromatic ever-green, that may be had perfectly good, and fit for the purpose, at all seasons of the year. But before it is made use of in our operation, it ought to be carefully examin'd as to its freshness, figure, surface, colour, odour, taste, strength, nerves, or vessels, the furrows of its leaves, and all the other circumstances that can possibly be thought of; for if any particular be omitted, the effects of the process will not be perfectly comprehended or understood.

## PROCESS I.

*Exhibiting the manner of obtaining those waters which spontaneously exhale from recent vegetables, in the summer-season, by a standard example in the plant* Rosemary.

*The process.*

1. H*Aving accurately view'd and scann'd our subject, and found it to be fresh-gathered, every way perfect, and fit for our turn; we commit it, pure as it is, without any mixture, to a cold-still, or simple furnace, so contriv'd, that it may, for a long time, be uniformly kept in a mild and gentle heat, not exceeding that of the summer's sun, by means of a soft, well-regulated fire; which forcing off the vapor, or most volatile part of the plant, it is condensed by the large pewter head*

*head, and trickles down the sides thereof into a proper vessel, placed at the end of the* rostrum *to receive it ; where it appears in the form of water* *.

2. This ascending vapor is not visible during the heat of summer, any more than about the plants, which by the sun are then made to exhale it into the open air; and wou'd entirely fly off and vanish, if the vessel that contains the subject were open: but since it is our business, as chemists, to render the changes we make in bodies observable to the senses, we catch and collect it by means of the pewter head; whereby those insensible fumes are render'd sensible, and prove, when caught and condensed, to be the dewy exhalations or fragrant water of rosemary. *Its effects.*

2. The liquor thus collected, we may, when the operation is finish'd, and the vessels disjoin'd, have an opportunity of examining with all the accuracy we are able; by comparing it with what remains behind of the original subject, as also with a fresh and perfect one of the same kind, which has suffer'd no alteration. The result of which examination is, in short, this; that the subject is divided into a liquid and a solid part; that the liquid part is larger in quantity, than could well be expected from so dry a body, and the small degree of heat employ'd for the purpose; that this fluid is the most volatile, fragrant and aromatic part of the plant, wherein its specific virtue resided; that the leaves, which before were full and turgid, are now shrunk and contracted in their bulk; that they have lost their natural taste and odour, and something too of their colour; and appear in all respects, as they would have done, had they lain exposed, for the same space of time, in the noon-day heat of the summer's sun. And hence we learn what manner of vapor is made continually to exhale from aromatic vegetables, during the summer-season; and in what an atmosphere we breathe, when we walk in odoriferous groves and gardens.

3. The advantages of this operation, perform'd in so easy and gentle a manner, are various and agreeable to those we said were required in the primary process of chemistry. For, (1.) We hence readily gain a knowledge of these parated parts, which, before the operation, undoubtedly went to compose the rosemary. 'Twill admit of no dispute, whether our odoriferous water, which has the specific taste and smell of rosemary, pre-existed in the plant; when 'twas obtained from it by such a mild and gentle operation, as did not destroy the figure of the subject. (2.) By this means also we acquire a knowledge of the remainder. If instead of the moderate heat, here made choice of, we had used such a violent fire as to burn the rosemary, it wou'd, for the greatest part, have been turn'd to smoke or flame; and the rosemary-ashes could not have been known for those of *Its advantages.*

* It might be proper to perform this operation in a glass vessel, the better to observe the condensation of the vapor, and the gradual change of the subject; without the trouble of unluting the still, or taking off its head at every turn.

this

this plant; but might as well have passed for those of any other. But as the operation was managed by gentle exhalation and exsiccation, without any previous fermentation, or other alteration, no body can possibly mistake the remains of the rosemary for any thing else; especially since the fire, being pure and clear, could not by its smoke, or otherwise, foul, deface or obscure any part of the subject. And, accordingly, the subject still appears to be rosemary; but rosemary dried. (3.) This mild and gentle process gives us an opportunity of examining the remaining matter, by new processes or operations. For after only the water is drawn out of a plant, we may easily try what substances it still contains; and, accordingly, we shall, in the following processes, see what kind of substances are left in the remains of our rosemary. (4.) We hence have a clear and distinct idea, both of the instrument, and the action, of our first process. Thus, when I see any plant whatsoever, which I once knew to be succulent, plump and green, become dry, wither'd and shrivel'd, like the remains of the rosemary of this process; I immediately know that the instrument which thus changed it, was heat: and also clearly conceive the manner wherein it produced this effect: which could be no other than that of our present process; the change procured wherein is evidently effected by heat. And since all manner of plants, except some ever-greens, wither and shrivel up in the heat of the furnace here employ'd; and since we observe, that the same effects are produced by the heat of the summer's sun; we may surely conclude, that the heat of the sun acts in the same manner with that of our furnace. The knowledge hence acquired is the more clear, distinct, and useful, as the operation causes no confusion in the parts of the subject. It is likewise absolutely necessary to begin with, and leads to the understanding of every process to come after it. For whenever I boil, calcine, or otherwise chemically treat rosemary with fire, the volatile water of this process presently exhales away; and therefore, unless I am acquainted with this water, I can never know what the subject is that I am treating, to which it naturally belongs. This operation, therefore, shews us what must of necessity, tho' perhaps without design, happen in all the other processes. (5.) And, lastly, We hence obtain an useful canon, or method for analysing all sorts of bodies; which ought to proceed by gentle and slow degrees, that the most volatile matter may have time to rise first; and all the parts be gain'd pure, distinct, and perfect. But if instead of proceeding thus gently, we had used a strong fire in our process, it would have burst the vessels of the plant, carry'd over such of its parts as shou'd have been left behind, and thereby have corrupted and spoiled the odoriferous water, and unfitted the remaining part of the subject for the next process; so that we shou'd thus have reaped no fruit from our labour. And, on the other hand, if the fire had been much gentler, nothing at all would have been raised from the subject. That such a kind of analysis is just, and separates the actual parts of bodies, might easily be made

made appear by thus dividing a mixture of two or more ingredients into its component parts; which may readily be done, by obſerving the cautions here given.

4. The vegetables which, on account of their medicinal virtues, ſeem fitted for this operation, are of the aromatic kind, or ſuch as have a pungent taſte and ſmell; the waters whereof, obtain'd in the manner above ſet down, are of a pleaſing ſcent, and agreeable flavour. The principal of them are theſe which follow. *The vegetable subjects which are fit for it.*

*A* CATALOGUE *of ſuch* aromatic vegetables, *as are proper to afford the* WATER *of the firſt* PROCESS, *for medicinal uſes.*

PLANTS.

Angelica.
Aniſeed.
Arſmart.
Baſil.
Baulm.
Calamint.
Calamus Aromaticus.
Camomile.
Caraway.
Clove-july Flowers.
Coriander.
*Coſtus Odoratus.*
Creſſes.
Cumin.
Dill.
Dittany.
Fennel.
Feverfew.
Galangal.
Garlic.
Hart-wort.
Hyſſop.
Jaſmin.
Leeks.
Lilly of the Valley.
Lilly, white.
Lovage.
Mace.
Marjoram.
*Marum Syriacum.*
Maſter-wort.
Maudlin-tanſey.
Mint.
Onions.
*Origanum.*
Roſemary.
Roſes.
Saffron.
Sage.
Savory.
Scurvy-graſs.
Southernwood.
Tanſey.
Thyme.
Tuberoſe.
Valerian.
Wild-thyme.

TREES.

ARBOR *Vitæ.*
Bay.
Box.
*Canella Malavarica*, or *Caſia lignea.*
Cedar.
Cinnamon.
Citron.
Elder.
Fir.
Guaiacum.
Juniper.
Lemmon.
Lime.
Maſtic.
Myrtle.
Orange.
Nutmeg.
Peach.
Pine.
Saſſafras.
Savin.
Storax.
Walnut.

5. The vegetables generally reputed proper for this operation, being only thoſe of the aromatic kind, the catalogue juſt now deliver'd, was form'd according to that notion; tho' without denying that plants which have neither ſmell nor taſte, might alſo be treated in the ſame manner to uſeful purpoſes: for ſuch plants may be endowed with great medicinal virtues in their exhalable parts. But I don't remember to have ſeen

seen any vegetables destin'd to this operation, but what were remarkable for their taste and odour. Any of the parts of vegetable substances may indifferently be chose for subjects of it, provided they are fresh gathered, as the wood, roots, bark, leaves, tears, gums, balsams, and the buds of trees and plants; but more particularly the seeds and flowers thereof. The water of the common spotted arsmart, obtained after this manner, is an excellent medicine, and proves wonderfully serviceable in case of the stone; for which purpose 'tis recommended by Mr. *Boyle*.

*The composition of the waters obtain'd from them.*

6. All the liquors thus gain'd from aromatic vegetables, are not simple and unmix'd, but consist principally of two different parts; *viz.* a large proportion of elementary water, and a very small one of a most fragrant spirit, wherein are lodged the peculiar taste and smell of the plant. This spirit will be obtained in its utmost purity and perfection, if it be separated and raised up by an exceeding clear, mild, and gentle fire, together with a proper proportion of elementary water; wherein it may be preserved good for a considerable time; provided the vessel that contains it be well closed; and especially if the operation has been twice or thrice repeated by cohobating, or pouring back the water, first obtained upon a fresh parcel of the plant; whereby it will be more fully saturated and impregnated with the sapid and odorous spirit, to which the mere water here proves no more than a vehicle; and which, with a great degree of probability, is supposed the effective cause of the specific, or peculiar virtues of vegetables. We are taught, however, by experience, that waters, which are both scentless and insipid, may nevertheless be possess'd of extraordinary virtues. These odoriferous waters are apt to grow foul or mothery by keeping; that is, they deposite a cloud, or light feculence, which contains the oily part of the water. To prevent which, 'tis a good way to drop into them, when they are first distill'd, a small proportion of the spirit of salt, or rectified spirit of wine. We do not therefore pretend that these odoriferous waters are perfectly pure, simple and uncompounded; especially since they contain a mucous part, without which it seems impossible to draw them. With all our care, we could never obtain a water entirely devoid thereof; or that deserv'd to be call'd perfectly pure and simple. That which has been drawn a year will become insipid and scentless, tho' at first gain'd in great perfection; but still we dare not pronounce what remains thereof to be mere elementary water: for, upon comparison, there will appear a great difference between them. 'Tis not in the power of chemistry to make things, or produce them in the manner that one might wish; all that man can do, is barely to separate and compound the parts of bodies: we are not able to bring any new thing into being, which did not exist before. The native spirit of every plant hath something in it that is specific, and inimitable by human art; and the taste and smell thereof are never

pro-

producible *. This ſpirit, however, we can ſeparate from the body of the plant, in a manner which, tho' not perfect, is yet ſufficient for our purpoſe: and he muſt be acknowledged the moſt perfect chemiſt who can make this ſeparation in the moſt exquiſite manner.

*The beſt way of diſtilling theſe waters.*

7. To gain theſe aromatic or fragrant waters in any conſiderable quantity, and to the beſt advantage, 'tis proper to draw them off in a copper ſtill, with a large pewter head, in proportion to its body; which will collect, condenſe and diſcharge the aſcending vapor in the greater plenty. By thus enlarging the capacity of their ſtill-head, the *Italians* have a great advantage over the other *European* nations in diſtilling odoriferous waters; their climate ſupplying them with excellent ſubjects for this purpoſe, and they treating them after a very artificial manner. A very clear and gentle fire is here to be adminiſtered; leſt by breaking the veſſels of the plant, and confounding its juices, the fragrancy of the water ſhould be impair'd. When therefore any very tender and delicate flowers are ſubmitted to this operation, a quantity of fine, dry ſand may be ſtrewed, to the height of an inch, between the bottom of the ſtill and the ſubject; which ſhould then be placed upon a fine, dry paper, ſpread over the ſand. And this is the way they make uſe of at *Catalonia,* where they diſtil the jaſmin-flowers in ſo great perfection. If poſſible, the heat employed ſhould not be greater than that of a ſummer's noon, which forces out the odoriferous exhalations we then meet with in ſpicy groves and gardens. With a great degree of cold, odoriferous plants prove ſcentleſs; and fetid with a great degree of heat. The ſubject ſhould be in its perfection, freſh, turgid, vigorous and juicy; or gathered at the time and ſeaſon when its ſcent is ſtrongeſt. Some plants are fit for this operation in all their parts; thus roſemary may be diſtilled entire, becauſe it is all over fragrant; but only the flower of the roſe ſhould be committed to this operation, becauſe its pleaſing odour is wholly confined to that. Either the whole plant then, or ſome particular parts of it, may be gently cropped, or gathered when fully ripe, without violence, or bruiſing the veſſels. This ſhould be done early in the morning, whilſt the cold dew is upon them, and, by ſhutting up their pores, keeps in their odoriferous and volatile parts. A roſe, for inſtance, gathered at this time, before 'tis fully opened, affords a much better, and more grateful water, both in ſmell and taſte, than one that was plucked whilſt the noonday ſun ſhone hot upon it, and expanded all its leaves. The plant muſt be fully ripe, provided it then affords its ſcent in the greateſt perfection. The lily and the hyacinth have no ſcent at all, till arrived at maturity, and full blown, but are then wonderfully fragrant; whereas the roſe is moſt odoriferous before it comes to be fully blown. The ſubject ſhould by no means be any way bruiſed or damaged in the gathering; for this would prejudice the ſcent thereof. Thus if a roſe, for inſtance, were to be pounded before it was committed to diſtillation, the

* This muſt be underſtood with due limitation.

other juices would mix themselves with the odoriferous water, and quite abolish or deprave the scent of it; so that what thus came over, could not be known for rose-water, as having quite different virtues and properties from that when skilfully drawn. Thus, as was before observed, the delightful fragrance of the jasmin-flower is lost, by barely crushing it between the fingers; and the pleasant odour of the lily render'd disagreeable and nauseous: which seems to proceed from hence, that the fine, volatile and odoriferous part of the plant is hereby mixed, confounded, and lock'd up in the more gross and viscid juices thereof. And lastly, the water drawn off should be suffered to rest for some days, closed up in the vessels which first received it; by which means the empyreumatical scent impressed upon it by the fire will wear off, and the liquor become clear and highly odorous.

*The usefulness of this process in natural philosophy.*

8. We come next to consider what light is afforded, or what useful truths are taught us by the foregoing operation, with regard to natural philosophy. The process it self, and the production thereof shew, (1.) What it is that exiccation deprives a plant of; *viz.* it's most subtile, fluid, volatile, sapid and odorous part, wherein its specific or distinguishing characters reside: whence we learn the difference between a fresh and perfect growing vegetable, and one that has been gathered, dryed, or exposed to a moderate heat. (2.) What it is that rises first in distillation; or what is the most volatile part of vegetables; *viz.* their proper spirit wrapp'd up in it's common vehicle, water. (3.) What is the effective cause of the peculiar taste and odour in a vegetable; *viz.* this native, or presiding spirit, which being drawn away, or suffered to fly off from the essential oil of rosemary, for instance, the oil immediately loses all its smell and taste; and which, without dispute, is but a very small quantity of matter, compared with the bulk of the plant, or its juices; and possibly not the hundred thousandth part of the water that contains it. For should an ounce of rose-water be exposed to the open air till its scent is quite abolished; tho' some of the elementary water must have gone off along with it, yet will the whole loss be scarce sensible upon the balance. Whence some chemists have expressed themselves, as if there were a certain little spark in bodies, which makes them what they are, and lodges it self in their salt or oil. And indeed this native spirit is neither oil, salt, earth nor water, but something differing from them all; as being too small in quantity, or too fine, thin and subtile to be caught alone, and rendered visible to the eye: tho' possibly it is no more than a part of the essential oil, most highly attenuated and subtilized. (4.) We hence learn what it is that constitutes the exhalations or effluvia of vegetables; *viz.* this same spirit, together with the elementary water which contains it, which is continually flying off from them, during the day time, in the form of an insensible perspiration. That this is no fiction, but happens as really in vegetables out of our furnace, as in those included in it, appears abundantly confirmed from history. We are told of trees in *Brasil*, which in a few hours time

time kill ſuch perſons as ſit under them; and of others that variouſly diſorder thoſe who ſleep in their ſhade. Some trees are declared capable of making people hoarſe by their effluvia; and others occaſion a ſpitting of blood, or an eryſipelas. The ſhade of the yew-tree is ſaid to be mortal; and the effluvia of the walnut will give the head-ach, ſtop a looſeneſs, or make a man coſtive. To walk in an orange-grove, while the trees are in bloom, gives the head-ach, a cold, and brings on a fit of drowzineſs. Saffron, if lain upon, will make a man ſleep; and 'tis no unuſual thing for roſes to diſorder thoſe who walk among them. I my ſelf knew a man to whom their ſcent would give the head-ach, a vomiting, a looſeneſs, and at length cauſe him to faint away. The ſcent of beans is ſaid to dull the brain; and hence the *Dutch* proverb, "you "have had a nap in the bean-field"; which is commonly made uſe of when a man talks from the purpoſe. Now, taking theſe facts for granted, as they cannot all well be denied, our preſent proceſs ſhews us how ſuch effects may be produced; *viz.* by means of the very water here obtained; which, during the day time, and eſpecially in warm climates, is plentifully exhaled from all manner of vegetables, by the heat of the ſun, and every way diffuſed like ſo many atmoſpheres around them: and theſe atmoſpheres, coming in at the noſtrils, or otherwiſe, may prove either wholeſome or noxious to the animals which are in them, according to the nature of the plant they proceed from. If rhubarb and hemloc were diſtill'd after the manner of our proceſs, the remains of the former wou'd loſe the purgative virtue of rhubarb, and become aſtringent; * and thoſe of the latter put off the poiſonous nature of the plant, and prove harmleſs to the body.

9. The principal uſe of this firſt proceſs, with regard to the art of medicine is, that it ſhews us how to obtain a water from vegetables, of great virtue in ſeveral diſtempers; as particularly in caſe of languor and fainting. For, as there ſeems to be ſomething of a relation between the animal and vegetable ſpirits; ſo in caſe of depreſſion, dulneſs, or even hyſteric or hypochondriac fits, nothing is more reviving than the odour of ſome aromatic plants, or the water gained from them by means of our proceſs: which water therefore is frequently uſed by perſons of the firſt rank in *Italy*, for their artificial fountains, that play at their entertainments. For this water paſſing out of the large perforated balls of ſuch fountains, in a thouſand different, ſlender ſtreams, diffuſes a moſt grateful odour around the room, without at all offending the head. For the elementary water, which ſerves the odoriferous matter as a vehicle, proves very agreeable and refreſhing; whereas were it wrapped up in inflammable ſpirits, the playing of ſuch fountains would prove very prejudicial to the nerves. Thus, when nothing elſe would give relief to an hypochondriacal patient, I have known the bare ſcent of the jaſmin-flow- *Its uſefulneſs in phyſic.*

* On this account rhuburb is commonly order'd to be torrified, or roaſted, to make it aſtringent.

er ſuddenly recover him. But this effect is only to be expected from the native vapor of the plant, or the odoriferous water which is drawn from it. The diſtilled or eſſential oil of the very ſame flowers might, inſtead of performing ſuch a cure, have cauſed the head-ach, or otherwiſe diſordered the patient. And whoever attempts to counterfeit the ſpecific ſcent of theſe odoriferous waters, by means of the diſtilled oils of the reſpective vegetables, muſt take care he does no miſchief with them; for they are apt to offend the head, if long ſmelt to; being in themſelves no more than a receptacle of the native ſpirit, to which, on account of their viſcidity, they afford a proper lodgment, and keep it from flying off too faſt. Now, as odours act ſo ſtrongly upon us, and may be made to affect us ſo agreeably, it might ſuggeſt a quære, whether medicines capable of anſwering ſeveral intentions, might not be exhibited in a new way, which ſounds more oddly than it appears irrational, I mean by the noſe; which is an organ liable to receive very little prejudice by odours of any kind. 'Twas before obſerved, that the atmoſpheres of trees and plants, by this means, variouſly and vehemently, according to their different natures, affect mankind; whence ſome are confeſſedly poiſonous, and others wholeſome. We have known roſes purge by their ſcent: we frequently ſee men intoxicated by vapours: and I once remember, that having a patient who was exceeding reſtleſs and delirious in a fever; I brought a bough of elder, with the flowers on it, into his chamber; and putting them into ſome warm water, they breathed out their native ſpirit into the room, after ſuch a manner, that the man was ſoon compoſed, and fell into a quiet ſleep; out of which he awaked greatly refreſhed, and afterwards recovered.

10. We have been the fuller and more particular upon our firſt proceſs, that we might lay a firm foundation, and prepare the way for thoſe which are to follow; all which will be conducted after the ſame manner, tho' without ſuch a tedious enumeration of circumſtances.

# CHEMICAL HISTORY *of the* Preparations *obtainable from* VEGETABLES *by* DECOCTION.

## PROCESS II.

*Exhibiting the method of making* INFUSIONS *and* DECOCTIONS *of vegetable ſubjects with water, by an example in the* REMAINS *of the firſt Proceſs.*

*The proceſs.* 1. UPON *the remains of the firſt proceſs, pour a quantity of pure rain-water, firſt made ſcalding hot by the fire, but under the degree of boiling; and continue them together in the ſame unvaried degree of heat, over a ſoft fire, the veſſel*

*being*

*being closed, which is called the state of digestion, or infusion, for the space of half an hour; after which time, if the liquor be strained or poured off from the subject, 'tis termed the* infusion *thereof: that is the liquor prepared by infusion or digestion from it.* (2.) *If after the subject has been thus digested, or infused, it be boiled over the fire in the same vessel, together with the former liquor, for a due space of time, as about a quarter of an hour; the liquor, now suffered to run thro' a sieve, or other strainer, from its subject, is called the* decoction, *or apozem thereof.*

2. The second operation in a course of chemistry ought in all respects, to bear a near relation to the first; to be performable after the same manner; and to depend upon, or be connected with it; consequently it should be performed upon the same, or a similar subject. We may therefore conveniently chuse the remains of the first process for the subject of this. And, indeed, that part of any vegetable which remains behind, after the first process has been performed upon it, may well serve for the subject of this; because the degree of heat employed, being here much greater than that of the summer's sun, or than that made use of in the first operation, whatever parts would be exhaled thereby, will, in an open vessel, fly off, and be lost to the infusion or decoction; so that the dry'd or preserv'd parts of vegetables may in some cases be as conveniently treated by this process, as those which are fresh and succulent; provided they be not otherwise damaged or corrupted. But then we are not to expect the native spirit of vegetables in such decoctions, or infusions. In order to infuse any fine, fresh, aromatic vegetable, so as at the same time to preserve its odoriferous or native spirit, 'tis an effectual way to perform the operation in a glass-egg, or vial, with such a long neck that the ascending vapor cannot rise high enough to escape. By this means we have rendered infusions much richer, and more serviceable in medicinal cases, than could have been expected from the common method of making them. The water for infusion should not be poured boiling hot upon the subject; because in that case it would dissolve too much of the resinous or oily parts thereof; whereas it is principally the saline portion of the plant that we require from this operation; which portion cou'd not so well be taken up by the water, if it was impregnated with unctuous or resinous particles; for oil in great measure prevents the mixing of salts with water. Besides, if the water here should be poured on too hot, it might, in a manner, burn up or scorch the surface of the subject, and induce such a crust thereon, as would not permit the plant to give out its virtue. On the other hand, if the water be too cold, it will not have motion enough to work upon the vegetable, so as to colour it self thereon, and dissolve its salts. When the water is first poured on, tho' the subject floats upon the surface; yet it should soon sink down, after its more soluble *Observations thereon.*

parts

parts come to be extracted by the menstruum; or the air, contained in the parts of the subject, to be forced out by the heat.

*Effects of the process when long continued.* 3. If upon what remains behind of the subject, after the decoction is prepared from it, fresh parcels of water be successively poured and boiled up with it, for the space of half an hour at a time; a fat, sapid, odorous, viscous, inflammable and frothy matter will constantly be found floating on the surface of the boiling liquor, as long as the water poured on extracts any odour, taste or colour from the subject; or till the water may be poured off from it, as pure, clear and insipid as it was put in. Thus therefore, by repeating the process, and continually scumming off the rising unctuous matter, there may at length be obtained a very large proportion thereof; which, being gently dry'd, will afterwards wholly burn and flame away in the fire: whence it appears to contain the oil of the subject; tho' not pure and unmix'd; for a proportion of salt also adheres thereto; so that in reality 'tis a kind of soap, yet not, like that, capable of dissolving perfectly in water. We are not to take this frothy matter for the recrementitious part of vegetables, as some wou'd persuade us; we shall hereafter have an opportunity of better examining into and learning its nature and composition. 'Tis very remarkable, that tho' the subject be boiled with fresh quantities of water almost ever so long, yet some of this unctuous froth is still cast up; so that almost the whole plant seems convertible into it. And by this means M. *Homberg*, as we find in the *French* Memoirs, reduced all the substance of the cocoa-nut into oil; excepting only a very small proportion of elementary earth. This unctuous substance lies obscured in the subject, till the salts are once dissolved and carried off; but after these are separated, it easily rises in the water; and being attenuated by the operation, becomes specifically lighter than that, and therefore floats upon its surface. Now, if after all this vehement action of the fire and water, we come to examine the remaining part of the subject, we shall find its pristine figure the same; tho' the leaves are swelled, and plump'd up by the water which has entered their pores: but if we dry them gently before the fire, they subside again, and appear in their natural size and form. However they are something decayed in point of colour, which is now blacker than we found it left by the first process. They have also lost their smell and changed their taste, which is now bitter, from the oil still remaining therein.

*The physical, and chemical uses thereof.* 4. Hence we learn, (1.) That the utmost force of boiling water is unable to destroy the structure even of a tender plant. Thus, tho' the flowers of the white lily be so exceeding delicate and tender; yet all the force of the fire that can act upon 'em, thro' water, will never change their figure. So that hot, or boiling water can do no more than extract the soluble parts from a plant, but never entirely dissolve it. And this may shew how the stalks and tender parts of vegetables are able to sustain all the action of the sun and rain without being damaged thereby; for the utmost

heat

heat of the ſummer's ſun is not equal to that of boiling water. Hence alſo, by the way, we ſee the reaſon why the human body is not diſſolved by the heat and motion of the blood and juices; and learn that our ſolids conſiſt not of ſaline or other matter capable of diſſolving in water. (2.) That an odour and taſte may be derived from inodorous and almoſt inſipid bodies. For the decoction of our preſent proceſs, which is both odorous and ſapid, was produced by boiling, with inſipid water, the ſcentleſs and almoſt taſteleſs remains of the roſemary, made uſe of in the firſt proceſs: therefore this new ſcent and taſte of the decoction muſt have been raiſed from ſome part of the vegetable, which was fixed with regard to that degree of heat whereto it was before expoſed. (3.) That infuſion and ſimple decoction are unable to extract all that is ſoluble in a plant, by the joint aſſiſtance of fire and water. By bare infuſion, ſometimes the colour and the odour of the ſubject, but always its taſte, remains in the liquor; eſpecially when the plant was freſh gathered, in its perfection, and the operation performed in a cloſe veſſel. (4.) That an apozem, or a decoction, differs conſiderably from an infuſion, on account of the greater degree of heat made uſe of in the former; whereby an apozem is fully impregnated, and ſaturated with thoſe parts of the ſubject which are readily ſoluble in boiling water. And the longer the operation is continued, the blacker the liquor grows, and the leſs it retains of the natural taſte and odour of the plant; eſpecially if the veſſel be left open, during the operation. If a decoction be prepared with a violent fire, and in an open veſſel, ſome part of the natural taſte and ſmell of the ſubject flies off every moment: which is an obſervation of great importance to a phyſician. In order to gain the full virtues of ſaſſafras-wood by decoction, a proper quantity, as, for example, about an ounce, being firſt raſped, or reduced into thin ſhavings, ſhould, in a cloſe veſſel, be put to boil in a quart of pure rain-water, for the ſpace of half an hour. If the operation were continued longer, and the veſſel not well cloſed, the ſcent or fine aromatic volatile part of the ſubject, would, in great meaſure be loſt to the apozem; but may, by proper management, be fully retained therein. The cloſer, denſer and heavier the ſubject is, and the more oil or roſin it contains, the leſs fit it is for decoction, and the longer it ought to be kept in infuſion, or digeſtion, to prepare it for that operation; wherein likewiſe it muſt be the longer detained before it will give out its oil. Thus guaiacum-wood muſt be infuſed for twenty-four hours, and then boiled for ſix more, before it will yield its roſin by decoction, ſo as to fit it for the cure of the venereal diſeaſe. 'Tis the practice in *Italy* to boil this wood, for the ſame diſtemper, till the unctuous froth appears upon the ſurface of the liquor. And in the ſame manner we ought to proceed when the ſubject is exceedingly reſinous or unctuous. The freſher, ſofter, and more juicy any vegetables is, the better is it diſpoſed for infu-

ſion

ſion or decoction; but, on the contrary, ſuch as are dry and old, appear leſs fit for either. In a recent plant, the ſalt and oil are mixed together; but in dry'd vegetables that have been long kept, there remains ſcarce any thing but oil: or if any ſalt happens to ſtay behind, 'tis ſo mixed and blended with the oil, as to require a deal of boiling to fetch it out. Thus the guaiacum-wood, as it is freſh cut from the tree in the *Weſt-Indies*, will, in half an hour's time, communicate a larger proportion of ſalt to the water wherein 'tis boiled, than it would here in *Europe*, where it can only be had dry and hard, by being boil'd ten times as long. And hence, perhaps, it is, that the decoction of this wood proves ſo much more ſucceſsful among them in the cure of the venereal diſeaſe, than it does among us.

*The ſubjects beſt fitted for it.*

5. The vegetable ſubjects which may moſt advantageouſly be treated by way of infuſion or decoction, for medicinal purpoſes, are thoſe of the aſtringent, acid, viſcous, or refrigerating kind; the principal whereof are included in the following catalogue.

A CATALOGUE *of ſuch aſtringent, acid, viſcous, or refrigerating* Vegetables, *as are proper to be treated by* Infuſion *or* Decoction *for medicinal uſes.*

| | | |
|---|---|---|
| ACACIA. | Ground-ivy. | Rhubarb. |
| Apples. | Hypociſtis. | Scordium. |
| Apricocks. | Hyſſop. | St. *John*'s-wort. |
| Barberries. | Knot-graſs. | Services. |
| Cherries. | Mulberries. | Shepherds-purſe. |
| Cinquefoil. | Myrtle. | Self-heal. |
| Comfrey. | Nettles. | Sorrel. |
| Cranes-bill. | Peaches. | Speedwell. |
| Currants. | Pears. | Strawberries. |
| Dandelion. | Pellitory. | Sumach. |
| Dwarf-elder. | Poppies. | Tamarinds. |
| Elder-berries. | Perriwinkle. | Tormentil. |
| Endive. | Plantain. | Water-lilies. |
| Fern. | Purſlain. | Wood-ſorrel. |
| Fumatory. | Quinces. | Wormwood. |
| Gentian. | Raſberries. | |
| Gooſeberries. | Roſes. | |

*Its uſe in medicine.*

6. The medicinal virtues of any of theſe vegetables may readily be communicated to the blood in the form of an infuſion or decoction, and mixing with it, perform their office according to their reſpective natures. And if ſuch infuſions or decoctions are drank down warm, they will be made to act by the general virtue of heated

water, which in the human body is highly deobſtruent and diluting, as well as by that which is peculiar to the plant; and ſo prove a means of conveying it farther. But ſuch infuſions, or decoctions, ſhou'd not be prepared from very oily, or very reſinous vegetables; for then they could not eaſily enter the mouths of the lacteals, or other abſorbing veſſels. That the ſpecific virtues of vegetables are, by this means, carried into the blood and juices, appears from hence, that if any one takes a doſe of the decoction or infuſion of the thick juice of *caſia fiſtularis*, the urine made ſoon after will be green; and whoever drinks a draught of the infuſion of rhubarb, or ſaffron, upon an empty ſtomach, will, in a quarter of an hour after, find his urine tinged of a high yellow, like the tincture of thoſe vegetables. So likewiſe if a woman, who gives ſuck, ſhould take the infuſion or decoction of ſena-leaves, her milk would, in two hours time, purge the infant at her breaſt. Whence it is very manifeſt, that ſuch medicines readily mix with the blood and juices. But when the medicinal virtues of plants reſide not in ſuch of their groſs parts as are ſoluble in warm or boiling water, the infuſions or decoctions will have no ſuch effect upon the body. But in order to heighten and improve their virtues, and fit 'em for ſome caſes to which they might otherwiſe prove unequal; the odoriferous water, drawn from the reſpective ſubjects abovementioned, by means of our firſt proceſs, may be added to the decoctions which are afterwards made thereof.

## PROCESS III.

*Exhibiting the manner of making* Robs, *or* Sapas, Defruta, Gellies *and* Extracts; *by an* Example *in the* Decoction *of the ſecond* Process.

1. L*ET the infuſion or decoction of the laſt proceſs be firſt clarified, either by ſtanding in a quiet place, by the ſtrainer or filtre, or by being boiled up with the white of eggs, and then committed to a clean, glazed, ſhallow, open, earthen veſſel, whoſe ſides widen upwards; which is to be placed over a clear, gentle fire, that the liquor may gradually exhale away, and the remaining matter gradually become of a thicker conſiſtence. When a decoction hath been thus evaporated, till one half of it is conſumed, the remaining part is called a* rob *or* ſapa; *tho'* ſapa, *in the language of* Columella, Cato *and* Varro, *properly ſignifies* muſt, *or new wine boiled half away in this manner. But we now uſe it, indifferently, for any freſh vegetable juice, or decoction, which is thus treated.* (2.) *When a decoction is thus exhaled away to a third part of its original quantity, we call the remainder* defrutum *: The Proceſs.

* The words *Sapa* and *Defrutum* are uſed by *Pliny* in the converſe ſenſe of what we here ſuppoſe them to mean; as may appear by the two following paſſages. *Nam ſiræum, quod alii hepſema, noſtri* ſapam *appellant, ingenii, non naturæ, opus eſt; muſto uſque ad tertiam partem menſuræ decocto: quod ubi factum ad dimidium eſt,* defrutum *vocamus.* Plin. Nat. Hiſt. Lib. xiv. cap. ix. *Vino cognata res* ſapa *eſt; muſto decocto, donec tertia pars ſuperſit.* Id. Lib. xxiii. cap. ii.

*tho' the ancients applied this word alſo to wine alone, boil'd after the ſame manner.* (3.) *When a decoction is thus waſted, by farther boiling, till the remainder becomes of ſuch a conſiſtence, that a drop of it let fall upon a cold marble, or the like, will there congeal, ſo as to tremble when 'tis touch'd, or to appear endow'd with an elaſtic property, we call this remainder a* gelly. *The ſame word is likewiſe applied to the freſh juices of fruits, or plants; as alſo to the broths of animal ſubſtances, inſpiſſated or reduced by boiling to the ſame conſiſtence.* (4.) *But when a decoction is exhaled away to the conſiſtence of ſtiff honey, or ſo far that, when cold, it will not ſtick to the fingers, 'tis termed an* extract; *of which there are two kinds, viz. the* aqueous *and the* reſinous; *the former whereof is made with water, and the other with ſpirit of wine. But both of them are ſaline, fat, bitter ſubſtances, and conſtantly appear of a very black colour. After the ſame manner may the recent juices of vegetables be prepared into an extract.*

*How to prepare ſubjects for it.* 2. When the liquor, or vegetable juice, to be exhaled away into any of theſe forms, or reduced to the conſiſtence either of a *Rob* or *Sapa*, a *Defrutum*, *Gelly*, or *Extract*, has its groſs and feculent, or earthy part ſo heavy, as to fall to the bottom of itſelf, and leave the ſubject pure and tranſparent, it may be ſufficient barely to let it reſt in a cool, quiet place, in order to prepare it for the operation; and when it has thus purged itſelf clear, to decant or pour off the liquor, by inclination, from its ſediment, before it has conceived any heat, or run into fermentation. If the feculence be light, and will not readily ſubſide, ſo as to leave the liquor clear, and fit for this operation; it may be depurated by the filtre, or by being ſeveral times paſſed through a double hippocras-bag, or flannel-ſtrainer; in the pores whereof, all the light feculencies, or groſſer matter, which made the ſubject thick and turbid, will by degrees be lodged; and the liquor paſs through clear and tranſparent. There is a thin or ſpungy kind of cap-paper alſo, which is known by the name of *filtring-paper*, very proper for this purpoſe in ſome caſes. A glaſs funnel being lined with a ſheet of this paper, the liquor that is poured into it will be tranſmitted, drop by drop, in a great degree of purity. Laſtly, when the decoction, or other liquor deſign'd for the ſubject of this proceſs, is ſo unctuous, fat and groſs, as not readily to fine itſelf down by ſtanding in a quiet place, it may moſt properly be clarified with the white of an egg, after this manner. Firſt, beat or whisk up the white of one egg, or more, in proportion to the quantity of your liquor, to a froth, in a clean veſſel by itſelf, and afterwards work in a little of the cold liquor along with it; then add more by degrees; and at length throw the portion ſo mix'd up, into the reſt of the ſubject, and juſt ſtir them together. Then ſetting the whole over a gentle fire to boil, as ſoon as the hard ſcum or cruſt riſes up, or juſt begins to break, remove the veſſel from the fire, and with a ſlice take off the head; and run the remainder, whilſt 'tis hot, through a flannel-bag; by which means

means the ſubject will be thoroughly depurated. For the white of the egg being mixed with the whole body of the liquor, and afterwards concreted or harden'd by the fire, it draws to, and intangles with it ſelf, all the viſcous, unctuous, and feculent matter it meets with, and can ſuſtain; then mounting to the top, on account of its comparative levity, carries that up along with it, and there forms itſelf into a ſtrong cruſt, which may be readily taken off, or ſeparated by the ſtrainer, ſo as to leave the ſubject perfectly fine and clear. The larger, the wider, and the lower the veſſel is, which we make uſe of in this proceſs, the better and the ſooner it is perform'd; becauſe the liquor will then exhale the faſter; whereas, if it ſhould be long in hand, the ſubject is very apt to receive ſome damage. This veſſel, alſo, ſhould, by all means, be of glazed earth, and not of copper or braſs, tho' lin'd on the inſide; for ſuch veſſels will be corroded by any decoction, or juice of a vegetable that is at all acid; and thence the ſubject will gain a vomitive quality, as I have frequently experienced.

3. The *robs*, *defruta*, *gellies* and *extracts*, prepared after this manner, are all capable of diſſolving in water, and may be kept for a very long time unaltered in their natures and virtues; provided the moiſt air is not ſuffer'd to get at them. They all perfectly retain the taſte and ſmell of the plant, as it was left in good meaſure deprived of both in our firſt proceſs, by the exhalation of its odoriferous water; and conſequently, theſe preparations muſt contain only thoſe virtues of their reſpective ſubjects, which neither reſide in the native ſpirit, nor in their ſolid, earthy, or feculent part. *Decoctions* and *extracts* differ only in point of conſiſtence, or as to the proportion of their aqueous parts; being both of them a kind of ſaponaceous bodies, conſiſting of oil, ſalt, and water. It ſeems impoſſible to obtain a decoction that ſhall be purely ſaline, without any mixture of oil, which, in ſome meaſure, will always remain in the extract; becauſe the degree of fire, made uſe of in that operation, is unable totally to expel it. But this is to be underſtood of that groſs, or fixed oil of vegetables, which they yield by long decoction; and not of the volatile or eſſential kind, that is gained from them by diſtillation. And hence we ſee the reaſon why all extracts are inflammable.

*The nature of the productions.*

4. The medicinal uſes and virtues of theſe preparations are exceeding great. For the decoctions or juices of plants may, by this means, be long preſerved perfect and entire, without ſuffering any fermentation, or ſuſtaining any greater loſs than that of their more volatile, aqueous, or ſuperfluous parts; ſo that at any time we may, by letting them down with as much warm water as they loſt in the exhalation, obtain the natural juices of vegetables in great perfection, capable of being applied to medicinal purpoſes, with all the advantages that would attend them, if they were freſh expreſs'd, and in their proper ſeaſon. All the ſpecific, or peculiar virtues of plants reſide in their juices, or

*Their medicinal virtues and uſes.*

or that part which is soluble by the heat of boiling water. The remaining parts are merely vascular, or composed of solid terrestrial matter, uncapable of receiving any change in the human body, or of communicating any virtues to it; proving the same in all kinds of vegetable subjects. Hence the several preparations afforded us by our present process, being freed from this terrestrial and inactive part, as well as from the aqueous, they are, *cæteris paribus*, more efficacious than the plants themselves, or their juices. And thus by boiling up the juice of quinces, for instance, to a due consistence, we may always have in readiness a medicine of great virtues, in cases of vomiting or looseness. And by such a contrivance, as this, it was that the antients obtained their portable wines. They took any quantity of must, or the fresh expressed juice of ripe grapes, and boiled it up, over a gentle fire, to an extract; which, when cold, they could carry with them on a journey; and so at any time, by diluting it with warm water, prepare a vinous beverage for their refreshment *. After the same manner, we may furnish our selves with portable medicines, fit to carry with us in a voyage to any part of the world; and capable of being used to as great advantage, as if the simples, we wanted, grew upon the sea. Thus, for instance, the extract of tormentil-root might immediately be brought back to a decoction, if an astringent liquor was required; and the rob of currants be diluted with water, if we wanted a drink of a refrigerating nature. But we are to observe, that to gain these preparations in their greatest perfection, the subjects should not be such as have been dry, or long gathered, but fresh, and in their full perfection; for, as we before observed, when plants are entirely deprived of their juices, no specific or medicinal virtues remain behind in their vessels or carcass; but all of them would then act in the body after the same manner; or, to speak strictly, they would none of them act at all. An effete, worn-out and exiccated poisonous plant might as safely be taken into the body, as any of those reputed the most innocent.

*The subjects best fitted for this process.*

5. The vegetables best suited to undergo this process, or to afford their robs, defruta, gellies and extracts, for medicinal uses, are all of the fix'd or astringent kind; such as we set down in the catalogue under the second process. But those of the aromatic tribe, or such as stand in the catalogue of the first process, are very unfit to be treated in the same manner; because their virtues consisting in those parts which are of a tender and delicate nature, they would exhale, and be lost in the operation.

*Introduction to the next.*

6. The remains of this process, which are the same with those of the second, being gently dry'd, obstinately retain their pristine figure; tho'

* The *portable-soop*, lately introduced, is a production of this process applied to animal subjects. Any rich soop, or animal jelly, boiled up to the consistence of glew, will be fit for the pocket, and ready, upon occasion, to be presently dissolved, with a due proportion of hot water, into a mess; which might be very desirable upon a journey.

they

they are now insipid, inodorous, dusky in colour, devoid of all the native or specific virtues of the plant, and render'd perfectly sluggish and inactive. They have already suffer'd the utmost violence of the fire that could possibly act upon them thro' water; we are therefore, in the next place, to see what alterations will be produced by a naked fire, acting immediately thereon.

## CHEMICAL HISTORY *of vegetable* SALTS.

### PROCESS IV.

*Exhibiting the manner of calcining, or reducing vegetables to white insipid ashes, by an example in the* REMAINS *of the second and third* PROCESS.

1. P*LACE the carcass or skeleton of our rosemary, left by the preceding process, in a dry, and clean, iron pan, to be held over a clear fire till it begins to glow, or become red-hot; then the subject will presently smoke, smell strong, grow black, flame, shine, sparkle, and at length sink into white ashes, which still retain the external form of the original plant; but this in so loose and tender a manner, that the least touch will immediately destroy it.* *The process.*

2. The fire, employ'd in this process, should be very clear, otherwise some saline part of the smoke might fall down into the subject, and impose upon the operator; by making him fancy it to be still sapid, tho', in reality, it was before deprived of all its taste by decoction, as it now is of all it's odour, by the flame which consumed its oil. *A caution to be observed in it.*

3. There appears to be two kinds of smoke, *viz.* aqueous and oleaginous: the aqueous is that which exhaled in our first process, and appears constantly white; but the oleaginous is always black, and consists of the oily parts of the plant, which being at first driven out by the fire, escape its farther action, that wou'd, if they stay'd longer behind, convert them into flame. The fetid scent here observable, is caused by the oil of the subject, which is now so attenuated, and rarified by the action of the fire, and its parts put into such a motion, that it has a power to strike the nostrils more vigorously than when it remain'd fix'd and condensed in the plant. The same oil is the cause that the subject turns black before, or during the time, it flames; for beginning now to be extricated and set loose, it appears in a greater quantity upon the surface; soon after which, 'tis turn'd into smoke or flame; till being all consumed, at length it leaves the subject white. As long as any of this oil remains behind, the body continues to flame *Phænomena thereof.*

flame, glow, or ſparkle; but that being gradually waſted, or gone off, in form of ſmoke or flame, the ſubject is at length left in the ſtate of a ſhining or glowing coal, and preſently after ſinks down in aſhes.

*Nature of the aſhes obtained by it.*

4. Theſe aſhes, which are as inſipid as ſand, and perfectly ſcentleſs, being firſt digeſted, and then boiled in water, communicate nothing that is ſaline thereto; and if the decoction is now ſtrain'd, purify'd and exhal'd away, not one grain of ſalt will remain behind; only a pure and attenuated terreſtrial matter, which, without great impropriety, might be called philoſophical or virgin earth.

*Nature of the ſubject.*

5. Hence we may learn what principles our ſubject remain'd poſſeſs'd of, after having been treated by the two preceding proceſſes; or of what parts all vegetables conſiſt, when they are deprived of all that was ſoluble in them, by the joint action of fire and water; *viz.* oil, and earth. For as nothing is inflammable but oil, 'tis certain that oil ſtill remain'd in our ſubject, notwithſtanding the long-continued action of the boiling water it ſuſtained in the ſecond proceſs, and the large quantity of oil which was, from time to time, ſcumm'd off the decoction. That it remain'd poſſeſs'd of ſome quantity of oil, may likewiſe appear from the blackneſs obſervable in the coal, whereto the fire at firſt reduced it; for oil is the cauſe of this blackneſs, and reſides in every body ſo long as it fumes, flames, and ſparkles; but when the oil is all conſumed, then the body loſes its blackneſs, and falls into a white earth or aſhes. And thus we ſee the reaſon why coals and ſoot are inflammable.

*The phyſical and chemical uſes of the proceſs.*

6. It appears probable, from this proceſs, that elementary earth compoſes the veſſels or ſolid parts of vegetables. It ſeems to follow, from ſome experiments made by Mr. *Boyle*, that pure water diſtilled ever ſo many times over, conſtantly leaves behind it a proportion of fine, white, virgin earth; from whence we may with ſome probability conclude, that the nutritious juices of vegetables, drawn into them in the form of water, depoſite this terreſtrial matter, or leave it behind them to form and conſtitute their ſolid parts: but this it ſeems unable of itſelf to do; and therefore requires the aſſiſtance of the oil we find in them, which adheres ſo tenaciouſly to it, that a great violence of fire is required to ſeparate them; and ſeems therefore, to act as a glew in binding the parts of the pure, white earth together. This earth contains nothing peculiarly medicinal, and is found the ſame in all vegetable ſubjects. 'Tis incapable of being diſſolved either by fire, air or water; and is, perhaps, the moſt perfect, pure and ſubtilized, that can any way be obtained by the art of chemiſtry. Even the focus of a large burning concave is unable to change or vitrify it, without an addition of ſand; with which it preſently runs into glaſs. Its being ſo fixed and unalterable in the fire, is the reaſon that the aſſay-maſters employ it to compoſe their teſts and cupels. Some alſo make uſe of it as a dentifrice; for it is a great abſorbent, and gives a fine gloſs or poliſh to the teeth.

7. The

7. The present process, compared with the foregoing, shews us that all the specific and distinguishing virtues of plants must necessarily reside in such parts, as are either dissolvable in water, or inflammable in the fire; and that the dryer or older any vegetables are, the more they lose of their native spirit, their salt and their oil; and the less their medicinal virtues. All plants by keeping lose of their weight. Their presiding spirit spontaneously exhales, which greatly takes off from their odour; their salts are diluted and attenuated by a moist air, as well as their oils, and rendered volatile, and carried off by a dry one. Thus any kind of wood, kept so long that it rots, falls of its own accord into ashes, without the help of calcination. And thus, as we before observed, the most poisonous, or the most medicinal simples may entirely lose their force and virtue by being kept too long. That horrid poison, the *Euphorbium* of *Mauritania*, will, with age, fall away into an indolent, innocent earth.

Hence also we see, in a nearer view, how it comes to pass that the vessels, or solid parts, of plants are neither destroyed by their own saline, aqueous, or oily juices, nor the external force that acts upon them: for their basis being of elementary earth, it can never be dissolved or changed by the action of the sun or water, nor by any of the parts or principles which enter the composition of their fluids. But if plants were wholly composed of saline and oily parts, they would soon be dissolved by the agents continually at work upon them.

It hence likewise appears, that there is no fixed salt in the solid parts of a vegetable: and the same holds true of animal substances. This may seem a paradox, tho' the truth of it is manifest from numberless experiments. But we need go no farther than the present process; the remaining ashes whereof are perfectly insipid as well as inodorous. 'Tis therefore a great mistake in those, who affirm that salt promiscuously resides in all the parts of vegetables; as well when they are dry and withered, as when they are fresh and green.

Lastly, we hence learn, that calcination renders vegetable subjects white, by depriving them of all their fetid oil, which it converts to smoke. And the same holds true also of animal substances. Thus in order to render the bones of a skeleton white, we endeavour to get out their oil, by laying them to steep in a *lixivium*, and successively exposing them to a warm dry air, which in time will carry off the oily parts, that make them appear of a yellow or dusky colour.

## PROCESS V.

*Exhibiting the manner of calcining vegetable ſubſtances into white, ſaline aſhes; by an* EXAMPLE *in the* EXTRACT *of the third* PROCESS.

*The proceſs.* 1. *TAKE the black extract of our third proceſs, lay it on a clean iron pan, and gradually dry it over a gentle, naked fire; it will preſently begin to ſmoke, ſmell ſtrong, grow blacker, boil up like pitch, take fire, and burn out with a clear flame, ſhine, ſparkle, and at length fall down into reddiſh aſhes.*

*Nature of the aſhes it affords.* 2. Theſe aſhes, if farther urged by the fire, become white and inodorous, but very ſaline, or fiery upon the tongue, and contain but little earth. Being digeſted and boiled in clear water, then ſtrain'd off and filtred, and the ſuperfluous moiſture evaporated, they yield a fiery ſalt, of a white or greyiſh colour. This ſalt differs in degrees of acrimony or ſharpneſs, with the plant 'tis gained from. The aſhes of all manner of vegetables are naturally ſaline, ſo far as we know: but the more pungent the taſte and odour of any one is, the leſs of this ſalt it affords: or, in other words, the greater their quantity of volatile ſalt, the leſs is that of their fixed; as evidently appears in horſe-radiſh, and other pungent or antiſcorbutick plants.

*Corollaries from the proceſs.* 3. From hence it appears, that boiling water gets out two different parts from vegetables, which may afterwards be reduced together into an extract, *viz*; (1.) an oil which will fume, grow fetid, exhale and burn away in an open fire, and is the cauſe of the blackneſs in the extract; which grows the darker as its bulk is leſſened by heat: and, (2.) a white fix'd ſalt, that contains a ſmall proportion of earth; and appears the ſame in all kinds of vegetables.

## PROCESS VI.

*Exhibiting the manner of calcining plants to white ſaline aſhes, like thoſe of the laſt, by an* EXAMPLE *in the* REMIANS *of the firſt* PROCESS.

*The proceſs.* 1. *THE remains of our firſt proceſs, or any recent plant, being firſt gradually dry'd with a gentle heat, and then placed in a clean iron pan, and expoſed to a clear, naked fire, will preſently begin to ſmoke, ſmell fetid, ſhine, ſparkle, flame, burn away, and at laſt fall down into aſhes, that retain the*

*the form of the original plant, after the manner of the ſubject in our fourth proceſs; only the ſmoke and flame in the preſent caſe are thicker and ſtronger.*

2. Theſe aſhes are white, inodorous, ſaline, or of a fiery taſte, and contain a conſiderable proportion of earth. When elixated, or boiled up in water, which is afterwards exhaled away to dryneſs, they leave a ſalt behind, perfectly like that of our fifth proceſs; and an earth like that of the fourth. *Nature of the production.*

3. By comparing together the ſeveral proceſſes which we have hitherto gone through it will appear, (1.) That all which the utmoſt force of fire, applied thro' water, can obtain from vegetables, is only their juices, and no part of their veſſels; which always remain undeſtroyed after ever ſo long decoction. (2.) That vegetables by boiling yield a large proportion of combuſtible matter, or oil, to water. (3.) That the ſalt and oil of vegetables are naturally ſo united in them, that the greateſt part of both may together be diſſolved, or gained from them by boiling water: or that the ſalt and oil of plants are by nature formed into a kind of ſoap, that is readily ſoluble in water; which oil alone, without ſuch a combination, wou'd not be. After the ſame manner as we find it in vegetables, ſo it is alſo in our ſelves: as long as the oil and ſalt are duly blended and kept together in our bodies, ſo long we are healthy; but if once this natural ſoap comes to be diſſolved, or its texture deſtroyed, then both plants and animals languiſh, ſicken and dye; unleſs proper remedies are ſpeedily applied. (4.) That 'tis the oily part of vegetables which gives the dark colour to the decoctions, or extracts prepared for them; for the ſalt, being perfectly white, has no ſhare in producing this colour. (5.) That the ſaline part of vegetables is more fixed than their oil. (6.) and laſtly, That the ſpecific or peculiar medicinal virtues of plants are owing to their native ſpirit or oil; not to their water, fix'd ſalt or earth, which appear to be the ſame in the whole claſs of vegetables. *Corollaries from the preceding proceſſes.*

4. Having now ſeen what effects, or changes, are producible in vegetable ſubjects with the two grand inſtruments, water and fire, ſeparate, or bined with air; and into what parts or principles they are reſolvable by means thereof; what is the office and uſe of their earth; and how fixed ſalt is obtainable from them; we ought in the next place to examine what this ſaline matter is, which remains after calcination; and under what form, together with the oil, it originally præexiſted in the ſubject. This is a piece of knowledge highly requiſite in a chemiſt, to enable him the more clearly and diſtinctly to underſtand the changes brought upon ſuch ſaline matter by the fire. A neglect in this particular might give occaſion to a very erroneous opinion in chemiſtry, by ſuffering us to perſuade our ſelves that ſalts exiſt in plants under the ſame form, and after the ſame manner, as they are produced, or made appear by the fire; which is directly oppoſite to the truth. *Introduction to the hiſtory of the eſſential ſalts of vegetables.*

truth. Thus an acid plant, as sorrel for instance, reduced to ashes, will afford an alkaline salt: but it would be a rash conclusion to say, that therefore sorrel is an alkaline plant; or that before the operation it contained an alkaline salt. All that cou'd fairly be concluded from such a process is this, that sorrel, treated in such a particular manner, afforded an alkaline salt.

## PROCESS VII.

*Exhibiting the manner of obtaining the* native, *or* essential SALTS *of* VEGETABLES, *from their crude* JUICES; *by an* EXAMPLE *in the* JUICE *of the plant* SORREL.

*The process.* 1. TAKE *any plant whatsoever that is ripe, fresh gathered, in its perfection, green, and full of juice, as sorrel for instance; bruise it well in a marble mortar, and then, with a press, squeeze it strongly out; wash, or boil the pressings twice or thrice with a moderate quantity of fair water, and squeeze them out again. Then mix the several liquors together; let them stand a little in a quiet place to settle, and afterwards run them thro' a flannel-bag, that all the liquor may become clear. When this is done, boil it up in a glazed vessel, over a clear, gentle fire, to the consistence of a thin syrup; then pour it into an unglazed earthen pan, and upon the surface of the liquor let a proper quantity of clear oil be lodged, to defend it from the external air. In this state let the liquor remain in a cool cellar for the space of six or eight months; and during this time there will shoot to the sides of the vessel a large quantity of a darkish, saline, crusty matter, which is the* native *or* essential salt *of sorrel; whilst an oily and terrestrial, or fat muddy part falls to the bottom; that being dry'd before the fire, and brought to a thick consistence, is combustible, and will burn away with a clear flame.*

*Cautions to be observed in it:* 2. This indeed is a tedious way of obtaining the native salt of a plant; but it is the shortest that I am acquainted with. The vessel, wherein the liquor is put to shoot, ought not to be of glass, tho' that wou'd have all the advantages of transparency, because its smoothness wou'd hinder the sticking of the salt to its sides; and so the operation be rendered still more tedious; but the juice easily insinuating it self into the pores of an unglazed earthen vessel, has a great advantage in shooting its saline spiculæ to the sides. And in this case, the want of transparency in the vessel may very well be supplied by that of the oil poured upon the surface of the liquor; which oil will give us the opportunity of observing the steps of the process, at the same time that by keeping out the air, it keeps the liquor from falling into fermentation, and prevents the vegetation and growth of mouldiness, or a mucilaginous substance

ſtance thereon; which would prove a very great impediment to the formation of the ſaline cryſtals; being it ſelf the ſalt now rendered in ſome meaſure volatile.

*The manner of its action.*

4. This cruſty matter, being freed from its liquor, ſeparated from the ſides of the veſſel, immediately waſhed clean from its adhering muclaginous fæces, by repeated moderate affuſions of warm water, and then gently dry'd, will exhibit the native ſalt of ſorrel in the very manner wherein it præexiſted in the plant; for this proceſs has done no more than barely freed the ſalt from the inſpiſſated juice; nothing being employed in it to cauſe a change but reſt; which ſuffered the ſaline parts ſpontaneouſly to ſhoot and form themſelves into cryſtals. And this is the only ſalt that chemiſtry affords us unaltered, or as nature produces it; in which caſe it never appears to be alkaline, from what plant ſoever it be obtained. And therefore it was well obſerved of *Helmont*, that the ſalt gain'd from vegetables by calcination, is greatly altered by the operation, and very different from the native or eſſential ſalt, or from what it naturally is in the compoſition of plants.

*The ſeveral ſpecies of eſſential ſalts.*

5. Theſe native ſalts differ in their nature and medicinal virtues with the plant to which they belonged; whence there comes to be a very great variety of them: but they may all be reduced and conſidered under three general tribes or ſpecies; *viz.* (1.) Thoſe of the acid, aſtringent, or very auſtere vegetables, as of unripe fruits, *&c.* which perfectly reſemble the tartar of wine. (2.) Thoſe of the ſucculent or watery plants; which contain but very little oil; ſuch as endive, ſuccory, fumatory, houſe leek, *&c.* and theſe come nearly up to the nature of nitre; being a very pure kind of ſalt, and readily ſoluble in water; whence they are commonly called nitrous ſalts; and on account of their cooling virtue come to be employed in burning fevers, and other inflammatory diſeaſes. (3.) and laſtly, Thoſe of the oily or viſcid vegetables; as all of the aromatic and agglutinant kind. Theſe afford it but in very ſmall quantities; or ſcarce at all, till by due courſe of fermentaion they have firſt thrown off their more viſcous and oleaginous parts. For oil and viſcid juices greatly obſtruct the ſhooting of this ſalt into cryſtals; whence they run rather into fæces and impurities, than any properly ſaline ſubſtance. But if once their oil be extracted from them, the remaining juice will readily enough afford ſuch a ſalt. Thus, from the unfermented juice of an aromatic, odoriferous plant, ſuch as mint, fennel, aniſe, *&c.* 'tis very difficult to gain the native ſalt. And hence it is that all fat wines, as canary, *&c.* ſcarce depoſite any tartar at all; but ſuch as are ſharp, thin and poorer, throw it off in very great plenty. Thus from the juice of tamarinds, or our preſent ſubject, ſorrel, this eſſential ſalt, is obtainable in great plenty; and from thoſe of the watery plants, ſuch as endive, brooklime, *&c.* which are not acid, in very large quantities; but then 'tis not ſo rich. We may therefore eſtabliſh it as

a kind of rule, that the more oily any plant is, the less native salt it will afford by the treatment of this process; and *vice versâ.*

*How they shoot in fermented juices.* 6. After the same manner, when any fermented juices of succulent vegetables, as those of summer-fruits for instance, and particularly of tart grapes, are committed to vessels of wood; they in time throw off their native salt, otherwise called tartar, or wine-stone, to the sides thereof; and this always in greater plenty, as the fermented juice or wine is the more spiritless, acid, austere, and of a thick consistence, before it was put up. If the wine be very rich and oily, twill scarce deposite any tartar at all; for which reason tis never afforded by must. But in such rich and unctuous wines, a matter falls to the bottom of the cask, in the form of an oily fæculence. The purer or more transparent and colourless the wine, the finer and whiter will be the tartar. Hence that of *Rhenish* wine is usually prefer'd to all other kinds. But when the wine is red, its tartar also appears of the same colour. We shall hereafter make it appear that these essential salts, afforded either by the crude or fermented juices of vegetables, are not in themselves simple or uncompounded bodies, but resolvable or reducible into water, earth, spirit, different oils, and salts of all kinds, fixed and volatile, acid and urinous; and from thence we shall learn in what form they exist in their respective subjects. For they will be found to contain an aqueous, and a viscous, acid, unctuous spirit; a large quantity of a very volatile penetrating oil, and a great proportion of one that is fixed and less penetrating; a considerable deal of the matter of a fixed alkaline salt; a very large proportion of earth; and to be of an acid, rather than an alkaline nature.

*Their medicinal virtues.* 7. The medicinal virtues of these salts being the same with those of their respective plants, they may be more commodiously and advantageously exhibited than the simples themselves, or their juices; because a less dose of such a salt will contain the virtues of a much larger of the plant; and is also readier to be reduced into a proper form for taking. Thus an ounce of the essential salt, or tartar of tamarinds, for instance, dissolved in any proper vehicle, and drank, will prove as purgative as thrice the same quantity of the fruit.

## PROCESS VIII.

### *Exhibiting the manner of preparing* medicated SALTS *from vegetables by calcination, after the manner of* TACHENIUS; *by an* Example *in recent* Rosemary.

*The process.* 1. PUT *rosemary, or any other green, recent, succulent plant, that has been gathered before it buds, or puts out its flowers, into an iron pan, close covered at the top with a plate of the same metal, and place it over live coals, that*

*that the subject may be gently scortched, without taking fire, or being made to flame, till the whole plant is reduced to a black body, or coal.* (2.) *Then the cover being taken off, the subject, thus torrefied, will begin to shine, sparkle and glow; during which time it must be continually stir'd about with an iron rod, till at length it ceases to give any more signs of ignition; or till it is reduced to white ashes.* (3.) *When these ashes cease to sparkle, and are grown perfectly white, put them into an iron pot, pour a proportionable quantity of rain-water upon them, and boil them together, over a naked fire, for the space of half an hour; or till the water has extracted all the saline taste from the ashes; which ought, in the mean time, to be frequently stirr'd up from the bottom with an iron ladle. Then filtre the lixivium, or run it thro' a double flannel into another wide and open iron vessel or pan; and in this exhale away the superfluous moisture, over a strong naked fire. But when the remainder begins to grow thick, let it be kept carefully stirring; and thus at length it will become dry, and when removed from the fire, appear in the form of a grey or dark-coloured mass, which is the* medicated salt *of rosemary, prepared after the manner of* Tachenius.

2. If this salt be now put into a clean iron crucible, covered to keep out the dust, &c. and committed to an open fire, 'twill flow like nitre; and if, after having remain'd for some time in this state, it be poured out upon a metalline plate, we shall have a saline mass farther purified than the former, and either of a whitish, or a brownish, a grey, or a lead-colour, capable of being cut into pieces of any figure. *Farther continued.*

3. This salt will be made still purer and finer by farther solutions in fresh water, and repeated filtration and exhalation; so that at length it might be brought into a fine transparent crystalline substance: but so much trouble is no ways requisite to fit it for medicinal uses.

4. The subjects designed to afford this salt in its greatest perfection, and to the best advantage, should abound but little in volatile salt, and be gathered in the leaf, before they put out their flowers; because at that time they most abound in salt: but after the spring is far advanced, and the flowers appear, they grow more oily, and lose a great deal of their saline part. And the more gently we proceed in torrefying them, the larger quantity of salt they will afford. 'Tis thus reducing the plant to a coal, in a close vessel, which stifles the fire, keeps in the smoke, and fixes the oil, that constitutes the manner used by *Tachenius* in the preparation of salts; which therefore go by his name, because he was the first who accurately described the process, in his *Hippocrates chemicus*: not that he was the original inventor; for they seem to have been more anciently known: and *Raymond Lully*, with many other chemists, were well acquainted with them, before the time of *Tachenius*. But if his method were not made use of, or if the plant were suffered to burn out in the open air, a great part of what is volatile in it would be lost to the salt; which, in that case, would become highly caustic or *The cautions it requires.*

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fiery: but this we would here avoid. The design of our process is not to give us a corrosive salt, after the common method in which the trading chemists prepare their salt of wormwood, by setting fire thereto, and burning it till all its combustible parts are consumed in a crackling flame or blaze; for by this means they can never obtain a balsamic or saponaceous salt, which ought to contain a proportion of oil; and which by our method is kept in it; whence our salt is also termed *medicated*, on account of the great virtues which, by this treatment, it comes to have in medicine, as we shall see hereafter. A coal is nothing but a terrestrial vegetable matter, wherein there remains such a proportion of oil, as renders it black, and combustible; and may be prepared as well from linen cloth, as the loppings of a tree; for they would then differ only in regard of their bulk or substance, and not of their nature. And if the subject of our process should remain stifled, or close covered down in the torrefying vessel, over the fire, for the space of a whole year, yet, during all that time, it would continue in the state of a coal; but if after this, the external air be let in upon it, the oil, that was condensed and fixed in the torrefaction, will immediately be in great measure consumed, and the black body appear in the form of whitish ashes. When the fire is thus suffocated or stifled in the subject, the ashes, to which it is afterwards reduced, are of a redder colour than those obtained by means of an open fire; and the more it is suffocated, the redder these ashes will prove: which shews that in such a case the oil is more intimately mixed and united with the salt of the plant. And the greater this degree of redness is, the better are the salts, and the less alkaline or fiery. When the oil is thus united with the salt, and fixed in it by the fire, they together constitute a saponaceous body, which will readily flow with heat: whereas the salts, prepared by an open flame, requires the utmost degree of heat to run them. If the fire were not sufficiently stifled in the subject, the colour of its salt will be too white. But 'tis scarce possible to determine the colour of it beforehand; there are so many circumstances which may cause it to vary. If a little smoke should any way mix therewith, 'twould turn it of a blackish colour; and thus sometimes it appears white, bluish, grey, or lead-coloured; but 'tis always esteemed the best for being of a brown colour, easy of fusion, and not corrosive or fiery.

*Medecinal uses of the preparation.*

5. The properties and medicinal virtues of these medicated salts, prepared after the manner of our present process, are very considerable. For, not being of a caustic or fiery nature, but of a proper saline taste, they come nearly up to the native salts of vegetables; as containing a large proportion of native oil, by means whereof they are the most mild and gentle of all the salts obtained from plants by incineration or calcination. They may also, on account of their virtues and saline nature, be used instead of common or sea-salt. Thus *Pliny* tells us of peo-

people, that live about the *Alps*, who, wanting the convenience of sea-salt, prepare one for themselves by burning the plants that the place affords, which serves them very well for their ordinary uses. They are not of a very alkaline nature; or greatly opposite to acids, of which they absorb or drink in but little. They relax or grow soft in the air, but can scarce be made to run therein; tho' they dissolve in water, and easily flow in the fire; by which last property they are distinguished from fixed alkaline salts. They readily mix with every fluid of the human body, except the oily, with which they unite more slowly. They with great ease enter, and with full force, into the blood, and the lympha; but it may be questioned whether they can ever insinuate themselves into the fine canals of the nerves, upon account of the grossness of their substance; for their *lixivium* will not pass thro' a large heap of sand; and we can find little or no taste in the spinal marrow, except in those parts of it where the blood appears to run. And this may be the reason why in nervous cases the art of medicine has no greater effect. They are capable of resolving the coagulated humors of the human body; and greatly attenuate the juices of it. They will not, however, dissolve the stone in the bladder; nor presently wear away the gouty matter that is once lodged and fixed in the joints. By their acrimony, they gently stimulate the solids, or vessels of the human body, without corroding them; and consequently they must necessarily prove deobstruent or aperitive; since they act as well by stimulating the solids, as by diluting and dissolving the fluids; in which operation they are greatly assisted by their gravity. They forward and promote both the natural secretions and excretions of the body: for whatever stimulates the solids, dilutes the fluids, or dissolves the coagulated juices, must necessarily sollicit and promote all manner of separation and evacuation, especially in the blood and lympha. And consequently they must be sudorific, diuretic and cathartic; and act as well in the *primæ viæ*, as after having passed the lacteals. Whatever thins the blood, dissolves the other juices, and opens the mouths of the subcutaneous vessels, so that the fluids plentifully derived thither may there pass off, is called a sudorific. Whatever does the same in respect to the glands of the kidneys, we term a diuretic: and that a cathartic, which after a similar manner, renders the fæces of the intestines moveable, by lubricating the passages, or deriving proper moisture plentifully into them, from the secretory vessels, with which they are lined; when the same stimulus, continuing to act, will sollicit their ejection by the muscles, whose office it is. Consequently, these salts must be serviceable in chronical diseases; where the *vis vitæ* is decayed, and a *vis inertiæ* reigns. All the physicians, from the days of *Hippocrates* down to the present time, agree in this, that chronical diseases proceed from a glutinous matter a viscidity, or a lentor in the vessels, which retards the freedom of their action; and if this be actually the case, a bet-

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ter medicine could ſcarce be contrived for the removal of them, than our medicated ſalts. Dr. *Sydenham*, tho'. an enemy to chemiſtry, was beholden to it for the ſalt of our proceſs; which he obtained by ordering the aſhes to be boiled in wine, and the ſtrained liquor to be drank in caſes of the dropſy. But we are to obſerve, that ſalts ſhould by no means be exhibited where the conſtitution is already ſaline, or where the ſolids are too weak to ſuſtain their action.

There are various methods of adminiſtring theſe medicated ſalts, which may be differently ſuited, according to the deſign or intention of the phyſician. But in general, they ought to be taken in a morning, upon an empty ſtomach, in the quantity of five grains up to that of a dram, or more, as the conſtitution may require, for a doſe; to be diſſolved in a proper proportion of fair water, for a draught. But when 'tis deſign'd to act as a cathartic, the patient ought over-night to ſwallow a few grains of aloes, made up into a pill; or half a ſcruple of the *Pilulæ Ruffi*; that the medicine, which is indifferent of itſelf, and undetermined to any particular way, may be directed to the *primæ viæ*, and exert its virtue upon them. To forward the operation, the perſon may, without danger, take a walk in the open air, ſo that he does not fall into a ſweat; for this is a thing that works with great gentleneſs, and gives no diſturbance to the body.

When we would have our ſalt work by urine, no purgative ſhould be taken on the night preceding; but ſome warmiſh liquor, ſuch as tea, whey, or the like, ought to be drank off freely, during the operation, in the morning. And by obſerving this direction, 'tis incredible what a quantity of urine will be diſcharged. For the ſame purpoſe, likewiſe, a light lixivium might be made, by diſſolving a ſmall proportion of our medicated ſalt in a large one of clean rain-water; by which means there will be inſtantly prepared an artificial water of greater virtues than thoſe of the diuretic ſprings, or even the *Spaw* itſelf, and capable of being drank in the ſame manner: the patient walking about in the cool air, which by contracting the excretory veſſels of the ſkin, will determine the fluids the more to the kidneys.

When it is intended to cauſe a diaphoreſis, 'tis proper to take it in bed, and to drink a large draught or two of ſome hot liquor upon it, ſuch as ſack-whey, ſage-tea, a decoction of ſaſſafras, or the like; and by this means it will admirably break away and diſſolve all manner of concretions or coagulations, form'd in the blood-veſſels or lymphatics. This ſalt alſo is a very powerful medicine in ſtubborn fevers, or tertian agues. The quantity of three drams thereof being diſſolved in water, and taken at ſeveral times, in the interval of two paroxyſms will ſeldom fail to cure an obſtinate tertian, or quartan ague. For by its penetrating and active virtue, it breaks away all ob-

obstructions in the capillaries, and opens a passage for the impacted matter to escape at, through the glands of the skin; whereby all the febrile lentor is at length dissolved, and carried clean out of the body. But, then we must be careful to what persons we use our remedy; and be well assur'd they are able to undergo the operation thereof; for it might prove of very ill consequence to give it to such as are phthisical, hectical, or labour under any inflammatory disorder. Lastly, our salt is an inestimable medicine in all hypochondriacal and hysterical cases. 'Tis surprizing how well it succeeds with valetudinarians, or patients of a sedentary, studious life, who are generally costive, and apt to be left more so by the common cathartics, after they have once perform'd their office; whence, by a frequent repetition of them, this sort of patients are commonly made worse than they were before. But our medicated salts are so friendly to the body, and so gently discharge the intestines of their load, as to leave the belly soluble, and the patient in an easy and composed state.

## PROCESS IX.

*Exhibiting the manner of preparing the* MEDICATED SALT *of the eighth* PROCESS, *from* DRY PLANTS; *by an example in dried* ROSEMARY.

1. *IF any green, ripe, succulent plant, be gathered in its proper season, when the weather is fair, and carefully dry'd in the shade, so as not to lose all the odoriferous water of our first process, and, as soon as it is dry, be treated in the very same manner with the subject of the eighth process; it will exhibit altogether the same phænomena, and afford the same kind of salt, only the subject in this case being dry'd or deprived of its superfluous moisture, before 'tis committed to the operation, the torrefaction will here be sooner perform'd.* *The process.*

2. Hence we are furnish'd with a way of preparing the medicated salt of *Tachenius*, with more expedition, ease, and cheapness, without at all impairing its virtues. *Its use.*

## PROCESS X.

*Exhibiting the vulgar method of preparing fixed salts, from vegetables, by calcination, after the manner of the trading* Chemists; *by an* Example *in the dry'd stalks of* Rosemary.

*The process.* 1. *LAY any dried vegetable, or part thereof, as here the stalks of rosemary, upon a clean open hearth; and with the flame of a taper, or the like, applied to the bottom of the subject set fire thereto, and it will immediately begin to smoke, crackle, or hiss, flame out, or blaze, and at length fall down into whitish ashes; which are to be stirr'd about with a stick, till they perfectly cease to sparkle.* (2.) *These ashes, thus kept moving about, till not the least spark of fire appears among them, will become very white and saline; and being treated after the manner of those in our eighth process, will afford a much whiter salt than that of* Tachenius, *at the same time that it is vastly more caustic, or fiery, more opposite to acids, specifically lighter, and approaching nearer to the nature of* fix'd alkali.

*Phænomena observed therein.* 2. In this operation we may observe, (1.) That in those parts where the subject flamed, there was no smoke to be seen. (2.) That the smoke at first was light and small, but increasing by degrees, grew thicker and blacker, and then vanish'd in a crackling flame. (3.) That the *apex* and sides of the whole flame were covered and sorrounded with a smoky cloud. (4.) That in those parts where the smoke was thickest, the flame broke out the soonest. (5.) That all the remaining matter which had any blackness in it, continued to burn; but as soon as ever the blackness disappear'd, the same matter would no longer be ignited. (6.) And, lastly, that if these ashes, during the time they were black and sparkled, were put into a close iron vessel, every way defended from the air, they would still remain ignited so long as any black speck was to be seen among them.

*How performable to best advantage.* 3. In order to obtain this salt in large quantities, to the best advantage, or the greatest profit, 'tis the method, when the first parcel of the vegetable subject is reduced to ashes, to lay more of the same kind upon them, and repeat the operation till the desired quantity of ashes is obtained: all which must be kept continually stirring about, so long as any apparent fire remains in them, or till they are become perfectly white. For as long as any plant either sparkles, or retains a blackness in calcination, its ashes will not dissolve to advantage by being boiled in water, or give out their salt thereto. It would be an idle attempt to go about obtaining any quantity of fix'd salt from black ashes, or coals; wherein it is too much lock'd up by the oil, which is the cause of their blackness; to be extracted with water. But when once this oil is entirely driven off by a proper ignition, the salt will easily dissolve away from the ashes.

4. We

4. We need not be curious in the choice of our ſubjects for this proceſs, if they are but gathered at the ſeaſon when they moſt abound in ſalt; ſince the vileſt vegetables may afford the ſalt we want from them, as well as the nobleſt. Thus it might as well have been prepared from bean-ſtalks, the cuttings of the vine, the loppings of the willow, the plant kali, hay, ſtraw, *&c.* without any remarkable difference from that afforded us by our roſemary. Nay, the mixture of a number of plants together will yield it, ſo as ſcarce to be diſtinguiſhed from the ſalt of any one particular plant; provided the requiſite care is taken in the preparation. From whence we have a remarkable inſtance of the power of fire or flame, to deſtroy the ſpecific medicinal virtues of all manner of vegetable ſubſtances. I will not, however, be poſitive that there abſolutely is no difference at all between ſuch aſhes, or ſuch ſalts of plants; but if there be any, 'tis too ſmall to be diſcovered by the joint aſſiſtance of all our ſenſes together. *The concluſions to be drawn from it.*

5. We have now ſeen, that there are two different ways of obtaining ſalts from vegetables; the one without the aſſiſtance of fire, and the other with it. (1.) Thoſe obtained without the help of fire, ſhoot, of themſelves, from vegetable juices, both before and after they have undergone fermentation; and theſe are called the native or eſſential ſalts of plants. (2.) By the aſſiſtance of fire, we obtain two other different ſalts from vegetables; *viz.* by calcining them, after the manner of *Tachenius*, and ſtifling the flame; and by burning them, or ſuffering them to flame away in the open air. The method of *Tachenius* affords us a ſalt in greater plenty than the other, on account of its keeping in the oil of the plant, and in ſome meaſure mixing it with the fixed ſalt thereof; whereby the ſpecific gravity of it is increaſed to almoſt the double of what it is in the fixed ſalts prepared after the manner of the ſhops. Whence we are given to ſee the foundation for a difference between the two, as to their obvious properties and medicinal virtues*. *The difference between this production and the former.*

## PROCESS XI.

### *Exhibiting the manner of producing* Fix'd Alkali, *or a moſt corroſive, fiery, alkaline ſalt, from vegetables; by an example in the aſhes of the tenth* Process.

1. PUT *the pure white aſhes of our laſt proceſs into a* Haſſian *crucible, and commit it to a ſtrong, open fire, for the ſpace of a few hours, ſo that the ſubject may be kept continually fluid, without vitrifying or* *The proceſs.*

* One of the principal medicinal virtues of the ſalt of this proceſs, is, that when mixed with a due proportion of the juice of lemmons, as in the quantity of a dram with three ounces of the juice, to ſtop any violent fits of vomiting; which it does in a ſurprizing manner. The ſalt of wormwood, indeed, is commonly preſcribed for this purpoſe; but the chemiſts well know, that a cheaper preparation will ſerve the turn.

*running into glaſs.* (2.) *Then the crucible being removed from the fire, and ſuffered to cool, diſſolve the aſhes in water; filtre the ſolution, exhale it away in an open iron veſſel, with a ſtrong heat, and keep it ſtirring about with an iron rod, or ladle, towards the end of the operation, till the remaining matter coagulates into a very dry and white maſs.* (3.) *Put this maſs into a very ſtrong crucible, cover it cloſe, and place it in a vehement fire, that the matter may run for two or three hours, upon which it will gradually turn of a blue or green colour; then pour it out into a metalline diſh, and it is the* fixed alkali, *or lixivious fiery ſalt we wanted.*

*Cautions to be obſerv'd in it.* 2. Great care muſt be had in preparing this ſalt, to pour it out of the crucible, into a pan that is perfectly dry; for ſhould the leaſt drop of moiſture be lodged therein, it would inſtantly break the veſſel into a thouſand pieces, and with a violent noiſe throw them all around, with ſuch a force, as wou'd be highly dangerous, or prejudicial to the lookers on. It might be more convenient, in ſome caſes, to pour it upon a dry metalline plate, rather than a veſſel, on account of the difficulty there would be to get it out; for unleſs, from its being firſt emptied out of the crucible, you keep it continually ſtirring to break its parts, it will preſently harden into a ſolid lump, and adhere ſo ſtrongly to the ſides of the receiving veſſel, as not eaſily to be looſen'd and freed from them. And if it be ſuffer'd to remain in this ſtate for any time, the air will run it into a liquor; for it is highly attractive of moiſture, and cannot poſſibly be kept dry in any veſſel, tho' of ſtone or metal, but one of glaſs; which alſo muſt be very cloſely ſtopped, to prevent its running. Nay, if it be kept in a glaſs, cloſe ſtopp'd with a cork, and tied over with a bladder, it will in time relent.

*Nature of the preparation.* 3. This ſalt is always the more corroſive, alkaline and fiery, the longer it was kept in fuſion, and the greater the degree of fire it ſuſtain'd; provided it was not vitrified thereby. During its ſtay herein, it continually changes from one colour to another, in the order of grey or brownish, white, blue, green, dusky, reddiſh, or marble-colour'd; according to which ſeveral colours, its degrees of ſtrength are gradually heightened, till at length it becomes ſo highly corroſive, that being ſlightly applied to the body of any animal, it immediately eats away the fleſh to the very bone; whence it ſeems to be nothing but a parcel of concentrated fire. There was a diſmal inſtance, mentioned by *Tachenius*, of this corroſive power of our ſalt at *Venice*; where a man, happening to fall into a large boiling cauldron of its lixivium, had all the fleſh taken off from his bones in an inſtant; ſo that the people, who immediately came to his aſſiſtance, drew out a perfect skeleton inſtead of a man.

*Whence obtainable.* 4. All manner of vegetable ſubſtances will afford this corroſive ſalt. Thus it may be prepared from their juices, decoctions, robs, *defruta*, ex-

extracts, essential salts, obtained either before or after fermentation, the medicated salt of *Tachenius*, and the several parts of plants. But different subjects yield it in different quantities; and require different lengths of time, and different degrees of fire to bring it to the requisite corrosiveness or acrimony. No subject affords it sooner, in greater plenty, or of greater strength than tartar, and the plant *kali*. The cuttings of the vine will also yield it to advantage. The *Russia* pot-ashes are prepared from the loppings of trees, after the same manner with those in the second step of our present process; and by the same means reduced to a dry mass, that breaks into lumps, which is the more esteemed for appearing of a blue or greenish colour; tho' they generally appear of a grey one. These caustic or lixivious salts, were heretofore prepared in *Egypt* only, from the thorny plant *kali*, which there grew in great plenty upon the sandy soil, near the sea-shore: and hence all fixed salts probably came to be called *alkalies*. The lixivium, or salt of this plant, they called by the *Arabic* name *Sotha*; and hence, at this day, the soap-boilers among us call the salt prepared in the same manner, *Soda*.

5. The fire employed in our present process, ought to be violent, or else the operation would proceed so slowly, as to require several days to finish it; but if the heat were raised to too great a degee, the subject would be vitrified, and so our labour be lost. For some proportion of earth will for ever remain in the salt, and render it liable to be converted into glass; which is nothing else but a mixture of fixed alkaline salt, and earth or sand run together by a very violent fire; in which operation the salt corrodes or dissolves the earth into a substance that is at first dark, but by the farther action of the fire, becomes transparent. And thus the ashes of all plants are capable of being run into glass by a strong heat, as *Zoar*, an antient commentator upon the books of *Moses*, has long ago observed. *And in what manner.*

6. The salt prepared after the manner of this process, is endowed with the following properties. (1.) A fiery taste; for if the smallest particle of it be applied to the tongue, 'twill prove extremely pungent, acrid, and corrosive, burn into it like a fire-coal, and cause an ulcer that requires some days time to heal again. (2.) No manner of smell; only when mixed with the saliva of the mouth, and held near the nostrils, it affords an urinous scent. But this does not seem to proceed from the fixed alkali, so much as from the saliva, which contains urinous salts. For 'tis the nature of our preparation to unite itself with all other salts, so as to suffer them to appear in their own form, and with their peculiar properties. (3.) A caustic virtue; whereby it will eat away and consume all the soft parts of a human body; and in time corrode even the bones themselves. (4.) An hostility to acids; with all which it makes a conflict, boils up, and destroys or changes *Its properties.*

changes their nature. (5.) A power of dissolving the various concreted juices of the body, except those of a stony nature. (6.) A faculty of uniting with all manner of gummy, resinous, and sulphureous bodies. (7.) A disposition to mix with all oily or unctuous bodies, so as to compose a soap: by which property it is that a lixivium of it readily gets the oil out of animal bones, and leaves them pure and white. Whence we have a method of preparing beautiful skeletons. (8.) A power of running all terrestrial substances into glass, by means of a strong fire. (9.) It relents in the air, and attracts a quantity of water out of it; which, tho' strongly detained by it, may again be drawn out by distillation. It also appears to drink in some acid salts from the air; because by frequently running *per deliquium*, therein it becomes a salt of a different kind. (10.) It is fixed in the fire. (11.) It compounds into a saline form with acids, which is determinable by them, so as to afford a variety of salts. Thus if it be put into spirit of nitre, it will successively attract the nitre, and it self become salt-petre. So if vinegar be poured upon it, the fluid will be converted into insipid water; and its acid parts remain absorbed by the fix'd salt. But in some mixtures it may afford neutral salts, of a middle nature between acid and alkali. In the spirit of alum it will turn into alum; and in the spirit sea-salt, it will become sea-salt it self. And this rule appears to be universal. (12.) It penetrates all the vessels wherein 'tis kept in fusion; especially those that are made of earth. And sometimes it will corrode the brass or iron cap, or stopple, of the glass which contains it, so that it may be crumbled between the fingers. (13.) It precipitates a red powder from a solution of corrosive sublimate in water; and turns the juices of violets, roses, turnsol, *&c.* of a green colour. (14.) When mix'd with thrice its quantity of chalk, bone-ashes, potters earth, or the like, and exposed to a violent fire, it cannot be brought to flow, but becomes volatile, and flies off into the air. (15.) Lastly, 'Tis a production of art, not of nature; and never to be obtained without the assistance of fire. * All true fixed alkaline salts constantly possess these properties, and may indifferently be obtained from all manner of vegetables, without retaining any thing of the specific difference observable between them; as Doctor *Slare* in the *Philosophical Transactions* of the royal society at *London*, has fully shewn. *Tachenius*, indeed, was of a contrary opinion. He supposed that all fixed salts constantly retained some of the nature and specific virtues of the particular plant that afforded them. And this may be true of the salts prepared from ashes which were not thoroughly calcined; and therefore have some part of the oil of the vegetable remaining in them; which may well cause a specific difference. But when such ashes remain long ignited, and are become perfectly white and free from oil, whatever was specific or peculiar in the plant, and depended upon its oil, is wholly destroyed thereby.

* The *Egyptian* nitre appears to be a natural fix'd alkali

7. The

7. The medicinal virtues of our fixed alkali are these. (1.) It destroys all manner of acids in the human body, wherever it meets with them. Oil of tartar will take off the violent acidity of oil of vitriol; and much more easily mortify the milder acids which lodge in the human body. (2.) It makes an ebullition or effervescence with acids; and after it is saturated, forms itself with them into a third kind of salt, of a neutral nature, and harmless or beneficial to the body. During this effervescence it moves it self every way from its centre of magnitude; and by this means raises the spirits that were oppressed by a suffocating acid. Thus in hysteric cases proceeding from an acid cause, this salt is of wonderful efficacy. It attenuates and resolves whatever was coagulated by acids; and breaks the texture of any glutinous matter. It disposes the oily parts of the fluids to unite with the aqueous, and blends them together after the nature of soap. It dissolves and breaks away all manner of coagulations formed by the bile, lympha, blood and serum, or any compositions of them. 'Tis endowed with a great stimulating virtue or acrimony, whereby it excites the nerves and fibres of the body, so as to make them perform their respective offices with briskness and vigor; whence it will prove diuretic, sudorific and purgative. And consequently it must be a powerful medicine in such diseases, as proceed from a lentor, or any glutinous, unctuous, acid matter lodged in particular parts of the body; such as the dropsy, where the liver and viscera are sound, the jaundice, the scurvy from an acid cause, the gout, *&c.* Thus in that species of the gout, which is caused by a predominating acid, a few drops of the oil of tartar *per deliquium*, taken once a week, in a glass of wine, is an excellent medicine; but must never be used when the body already abounds with alkalies. And in all hot and inflammatory constitutions and diseases, all colliquative or malignant fevers, the small-pox, the measles, all pestilential cases, and wherever the body tends to a state of alkaline corruption; when the blood is in too great motion; where the solids and fluids are too much dissolved and melted down by a long continuance of chronical diseases; where there are signs of a predominating volatile alkali; where the bile is too much diluted and attenuated; and where the lungs are ulcerated, *&c.* in all these cases our salt must be avoided as poison; because it would here increase the disease, and might easily prove mortal. This salt may be safely used internally, after the same manner as was prescribed in administring the medicated salt of *Tachenius*: but the dose of this ought not to exceed a third of that; and requires to be diluted with a larger proportion of water. In cases of chirurgery, our caustic salt is of very great use; for it excellently cleanses and deterges foul, sanious or phagedenic ulcers; instantly puts a stop to gangrenes and mortifications; takes down fungous flesh, and wears away all manner of excrescences, as warts, the callous lips of wounds, *&c.* It likewise serves to make issues, and to open tumors, in order to dis-

*Its medicinal virtues and uses.*

diſcharge the matter of them: but it cannot be well applied in nervous parts; becauſe of the great pain it wou'd in that caſe excite. To ſtop a gangrene, we need only draw a line with it about the affected part, which will immediately cauſe an eſchar, that, like a bar, prevents the miſchief from ſpreading farther: or if it is come to a mortification, the part ſhou'd firſt be ſcarified, till the ſound fleſh appears; and then ſome of the lixivium of our ſalt, being applied thereto, will induce an eſchar, which may be afterwards ſeparated in the common manner. Foul ulcers need only be waſhed with a lixivium of it; and fungous fleſh, the callous lips of wounds, warts, *&c.* be gently touched with the ſalt it ſelf in ſubſtance. But to open tumors, or make an iſſue, a ſmall portion of it ought, for ſome time, to be kept upon the part, with a proper bandage. Laſtly, this ſalt will afford us an admirable, ſafe and innocent coſmetic, to cleanſe the skin and take away the freckles, ſpots, or breakings-out that are apt to deform it; as M. *Homberg*, in the *French* Memoirs elegantly informs us. To which purpoſe we need do no more than diſſolve a little of it in a conſiderable proportion of water, and frequently uſe the liquor as a waſh.

## PROCESS XII.

*Exhibiting the manner of purifying the* FIX'D SALT *of the eleventh* PROCESS, *by running it* per deliquium.

*The proceſs.* 1. *PLACE the fiery alkaline ſalt of the preceding proceſs in a crucible of earth or iron, and commit it to a proper charcoal fire, that the ſalt may flow, for the ſpace of four or five hours; or till it becomes of a reddiſh colour and vehemently cauſtic.* (2.) *Diſſolve this in ſalt water, and let it ſtand in a cool place till it depoſites a ſaline matter, in the form of cryſtals, of a bitter taſte, tho' neither acid nor alkaline, but ſomething* ſui generis, *at the bottom to the containing veſſel; and which is afterwards with difficulty ſoluble in water. If now the liquor that floats above this matter be exhaled away, it will leave a purer ſalt behind it; which being again committed to the crucible, and placed in the former degree of fire, will become a moſt violently corroſive and fiery ſalt.* (3.) *Let this ſalt, thus prepared, be expoſed in a wide and open glaſs veſſel, to the air of a cool cellar, and it will ſwell, relent, grow ſoft, and, at length, in part diſſolve into a thick and heavy fluid; which is to be committed to the filtre. The matter which remains behind undiſſolved, muſt be expoſed to the air again, till 'tis fit to paſs the filtre; and the ſame operation being repeated occaſionally, the whole quantity will at length be reſolved into a limpid liquor, and a portion of ter-*

*reſtrial*

*restrial matter or fæces, incapable of any further solution. The limpid liquor separated by the filtre, is called by the name of an alkaline oil, or oil of tartar, made* per deliquium.

2. If this limpid liquor be suffered to stand for any considerable time in a quiet place, saline crystals will form themselves at the bottom of the vessel, which cannot so easily be produced by any other method. And if the same transparent liquor, prepared *per deliquium*, be again exhaled to dryness, dissolved in the air, and fused in the fire, for a number of times successively; it will at the last go off wholly into the air; leaving only a small proportion of earth behind it. *Continued.*

3. The vessel wherein the salt is set to run, should be of glass, or glazed earth at least, because 'tis apt to corrode those of any other matter; and it should be wide and open that the air may freely come at the subject to dissolve it. The liquor, that is thus made to flow by the moisture of the air, ought rather to be decanted off, pure and limpid, from the remaining part of the subject, that is not hitherto dissolved, than be committed to a filtre of paper, to fine and purify it; because, as paper is made of linen rags, beat to a pulp, which is fastened or held together by starch, the liquor is apt in passing thro' it to dissolve this glutinous substance, whereby the salt becomes impure, and afterwards deposites the greater quantity of fæces when it comes to be run afresh. The liquor, thus prepared, seems to have obtained the name of oil, upon account of the unctuous state it appears in when first 'tis run, or before 'tis decanted off from its fæces, or purified by the filtre: not that it really has the properties of an oil; for it is not inflammable, but if thrown into the fire will put it out. The fæces which remain after the operation is finished, are merely terrestrial, and commonly appear of a black colour; notwithstanding the liquor which deposits them is pellucid, and the salt, at length, so white. The process of preparing this lixivium *per deliquium*, is called philosophical filtration, on account of the impossibility of further resolving the terrestrial fæces it leaves behind it, or bringing the salt to a greater degree of purity. The specific gravity of our oil is very considerable; it being the heaviest fluid we know, excepting quick-silver and oil of vitriol; and making an excellent menstruum, and as pure and strong a liquid alkali or lixivium, as chemistry can afford us. *Cautions and observations relating to it.*

4. If in order to prepare the salt of the eleventh process for the business of this, we should add to it thrice its own quantity of any matter that would prevent its fluxing, as tobacco-pipe-clay, chalk, or rather bone-ashes, and thus expose them to the fire after the former manner; we shou'd obtain a very corrosive salt, and fit for our purpose. But then, tho' the salt might be rendered sharper by this means, because more fire would be fixed in it during the operation; yet a large quantity of the salt it self must necessarily be lost, because being now rendered volatile, it wou'd fly off into the air. To hinder the flowing of a subject, promotes the action of the fire upon it; which cannot sustain so great a violence, *To vary or improve it.*

olence, when kept in a perpetual flux. Thus if a quantity of sea-salt were kept in fusion, for the space of twelve hours, it would suffer no change by the action of the fire during that time; but if thrice its own quantity of bone-ashes be thrown along with it into the crucible, this would keep it from fusing; so that by the action of the fire, it would, in the same time, be render'd so sharp, as afterwards to afford a corrosive spirit; tho' a large part thereof must necessarily have flown away in the operation.

## PROCESS XIII.

*Exhibiting the method of preparing the* common caustic, *or the strongest and most fiery of* FIX'D ALKALINE SALTS, *with quick-lime, for chirurgical uses.*

*The process.* T*AKE of the fine dry quick-lime of* Liege *one part, strong* Russia *pot-ashes two parts, place the ashes upon the lime, and expose them together, in an iron vessel, to the air, till the lime falls to pieces, or appears to be slaked; then pour upon them four times the whole quantity of hot water, and boil them together for some hours; afterwards decant the clear liquor, and run it hot thro' a filtre of linen, several times doubled, and exhale it over a strong, open fire, till it comes to a dry mass; which being put into an iron crucible, is to be committed to a gentle heat, and there to be kept for some hours, during which the matter will flow like wax; then pour it out upon a dry, copper plate, and presently, before it grows too cold, cut into oblong pieces of a convenient size; which are immediately to be put up into a dry, warm, glass vessel, and secured from the air: and thus we shall obtain a proper* caustic salt *for chirurgical uses.*

*Phænomena observed therein.* 2. The pot-ashes being here made to relent, and dissolve, by the moisture of the air, this serves to slake, or extinguish the quick-lime; from whence we have a kind of dry effervescence, in which the fire of the lime being joined with that of the ashes, they together afford so strong a *lixivium* with water, that if the finger were to be put into it whilst 'tis boiling, it would instantly eat it away to the bone. This *lixivium* also will suddenly destroy paper; but linen is better able to sustain the force of it, which therefore is here made choice of for the filtre, or strainer; for it would presently dissolve any woollen substance to a gelly. 'Tis the property of the salt thus prepared to flow in a gentle fire; whereas the alkaline salts, prepared in the vulgar method, require a vehement one to flux them. There is scarce any thing which chemists have more eagerly sought after, as particularly *Paracelsus*, and *If. Hollandus*, than to incerate fix'd alkalies, as they term it; that is to reduce them, as it were, into the state and form of wax: which problem is now solved by means of the present process. For after our salt is poured

poured out upon the metalline plate, it may, before it grows too cold, be readily cut and divided with a knife into parts of any figure, which to fit for chirurgical uſes is commonly cylindrical; for it will retain any figure after it is thoroughly cool'd. But when once it is thoroughly cold, it becomes too hard to be managed at this eaſy rate. For after it has continued in fuſion for ſome hours over the fire, it commonly appears of a green, aſh, or dark brown, which laſt is the colour that denotes it to be moſt highly ſharp, corroſive and fiery. This ſalt eaſily relents in the air, and runs into a reddiſh liquor, as it were of a fire-colour, tho' that of the matter it ſelf was contrary thereto. This liquor, if permitted to ſtand at reſt for ſome time, will depoſite a proportion of a terreſtrial or ſtony matter: and ſo powerfully does our ſalt attract the moiſture from the air, that I have ſeen it melted down in the containing glaſs, ſome time after it has been put up hot therein; tho' the veſſel was firſt well dry'd and heated, and its mouth afterwards exactly cloſed with a cork and oiled bladder, three times doubled. If the lime be ſlaked before 'tis made uſe of in this proceſs, the pot-aſhes will be leſs fiery, and the ſalt prepared from them of leſs virtue and efficacy. Therefore, the cauſtic property of this ſalt appears to proceed, in great meaſure, from the fire that is lodged and concentrated in the lime, and aſhes; as well as that which they afterwards gain in the operation. But it is very remarkable, that the cauſe which makes our ſalt more corroſive, ſhou'd, at the ſame time, diſpoſe it to flow with readineſs in the fire. But when long expoſed to the air, it loſes its corroſive virtue, and runs into a liquor.

3. This ſalt is one of the moſt violent cauſtics we have, and preſently liquifies and diſſolves all the parts of a human body, as well ſolid as fluid; and conſequently muſt be very ſerviceable, when properly made uſe of, in chirurgical caſes. I make no queſtion, that if this violent alkali were taken internally, in the quantity of but of a few grains, it would ſoon liquify, and diſſolve away the very ſtomach it ſelf. It ſeems to come very nearly up to the nature of peſtilential ſalts, or thoſe which cauſe the plague among us: only being more groſs or fix'd than they, it acts chiefly upon the larger veſſels of the human body; whereas the peſtilential ſalts, being more ſubtile and volatile, are fitted to act upon the ſmaller parts thereof; and ſometimes without appearing to affect the larger. But ſome degree of heat or moiſture is abſolutely required to bring our fix'd ſalt into action: when applied to the lifeleſs body of a man, it has no effect thereon. But being apt to run, flow and relent with very little heat, and very little moiſture, 'tis wonderfully diſpoſed for action; and becomes a moſt preſent remedy to ſtop the ſpreading of a gangrene, or mortification.

*Medicinal uſes of the production.*

*Corollaries from the history of vegetable salts.*

4. Having now resolved our fixed salts up to the highest degree of simplicity and purity they are capable of being brought to by art, and increased their strength to the greatest degree we are able; let us see what conclusions may be drawn from the preceding history of them, as to their nature and production. (1.) It appears from our several processes, that the fixedness of these vegetable salts depends upon the action of the fire. Thus we can obtain them, by means of it, from all sorts of fresh, succulent plants, or such as are not too much dry'd or decay'd; but if vegetables to be thus treated, after having very long lain exposed to the air, they will yield no fixed salt at all: for in that case the air has left them in the state of the subject of our fourth process. The matter therefore of these alkaline salts is originally volatile; but rendered merely fixed by the operation of the fire. (2.) That they are the production of the fire; for there are no plants which manifest the least sign of an alkaline salt before incineration. The juices of plants are tartareous, oily, aromatic, acid, *&c.* but never alkaline. Our second process performed upon what vegetable subjects soever, will never extract an alkaline salt from them. But we constantly observe, that the greater the fire made use of in the incineration, and the better that is performed, the more of these alkaline salts we obtain. (3.) That alkaline salts are not the native or essential salts of plants. For being mere creatures of the fire, they cannot præexist in a plant, and therefore were not natural to it: nor do they ever appear till the plant it self is totally destroyed; whence they cou'd not possibly be native, or essential. And consequently the native or essential virtues of vegetables do not depend upon such an alkali. (4.) That they do not naturally præexist in the subjects which afford them. I know that M. *Homberg*, an admirable and judicious chemist, is of another opinion; and therefore shall here endeavour to strengthen my own by an example or two. The plant sorrel confessedly contains an acid salt, and in what manner soever you examine it, without destroying the body of the plant, you will find it either acid or insipid, but never alkaline. But burn it to ashes, and it will afford our alkaline salt; provided it has not been too long exposed to the air. Whence I think it evident that such a salt did not exist in the plant, before it was reduced to ashes. We have already observed, that when any vegetable substances are kept too long, they lose their colour, smell and taste; and, when calcined, afford nothing that is saline in their ashes: and as this is the common case of all plants, what can hinder us from concluding, that the salt which thus vanishes, and is lost to the plant, was not a fixed alkali, but a volatile salt; since it is carried off, and made to exhale by so gentle a cause as the action of the air? And thus, if a whole lime-tree were reduced into thin shavings, and exposed for any considerable time, to the open air, and afterwards calcined, it would not afford a single grain

grain of fixed ſalt; provided the ſhavings of the wood were made ſufficiently ſmall and thin. The matter, therefore, which in a recent vegetable affords the fix'd ſalt, is ſo volatile, as in time to fly off ſpontaneouſly from its ſubject; and conſequently no fixed ſalt does naturally præexiſt therein. (5.) That infinite ſpecies of ſalts may interpoſe between the fiery alkaline ſalt, and the native one of vegetables. Thus tartar, for inſtance, or the mild, and ſomewhat acid eſſential ſalt of grapes, will, with different degrees of calcination, ſucceſſively appear under different colours, according to which, it will have different degrees of ſharpneſs or acrimony. But it does not become acrimonious upon the firſt action of the fire; but rather fat, unctuous and black, ſo as in that caſe to afford the matter for the printer's ink; but the longer it is torrefied, or calcined the farther it is removed from its original or natural ſtate, and the more alkaline it grows. So that the ſalt of plants is always mildeſt in the ſtate wherein nature affords it; and continually riſes in corroſiveneſs, with the degrees of fire to which it is expoſed. There may, therefore, be infinite ſpecies of ſalts, and of different colours, between the native, and the laſt claſs of fixed ones afforded by vegetables. (6.) That the difference of ſalts, prepared by calcination, principally depends upon three cauſes, *viz.* 1*ſt*, The greater or leſs quantity of combuſtible matter, or oil, that adheres to the ſubject, or aſhes; 2*dly*, The ſtrict or looſe union of the oily principle with the ſaline; and, 3*dly*, The quantity of fire, fixed, and made one with the ſalts themſelves; or elſe the matter of it acting upon, and changing them, till they are uncapable of any farther alteration. The greater quantity of oil any ſalt contains, the farther it is removed from the ſtate of a perfect alkali. Thus, if tartar be torrefied, ſtifled, or lightly calcined to a black coal, it will become a benign and gentle medicine, capable of affording a fine lixivium with wine, and very proper to be given in dropſical caſes. But the more its oil is conſumed by the fire, the more ſharp and corroſive it grows; and at length, being ſtill farther urged with the fire, which conſumes its oily parts, it will turn to a violent, fiery, and white cauſtic ſalt, reducible by oil to a mild and inoffenſive nature again. If we take two ſingle pounds of tartar, and calcine the one in a ſtrong, open fire, but barely torrefy and ſuffocate the fire in the other; the ſalt afforded by the latter will be more in quantity by a third, than that afforded by the latter; and of a much more gentle nature. And thus according to the care and ſkill of the artiſt in burning his vegetable ſubjects, they will be made to yield a greater or a leſs proportion of a mild, or fiery ſalt. For by means of a gentle heat, we ſee that the oil of a plant is intimately united with the ſalt thereof. We formerly obſerved in our *Theory of chemiſtry*, that the moſt ſubtile body of fire might be fixed; and tho' it were to remain in that ſtate for the ſpace of a hundred years, yet being at length, by ſome means or o-

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ther, ſet free, it will appear in the form of fire again. Thus if quicklime, for inſtance, be kept in a dry place, where no manner of moiſture can come at it, for ever ſo conſiderable a number of years, and afterwards be plunged into water, 'twill boil and bubble up with great violence and fury; upon which the fire is preſently loſt to the lime, and communicated to the water, which now makes the ſpirit in a thermometer to aſcend; but being now ſet more at liberty than it was before, it ſoon flies off into the air: whence we may ſee, that quicklime is nothing but a parcel of fire lodged and detained in the groſs, ſtony, or terreſtrial matter whereof all lime is made. And after the ſame manner the fire enters, and wou'd make its eſcape from our fix'd ſalts, but remaining fixed therein is the cauſe of their corroſive, or cauſtic virtue; for they act altogether in the nature of fire. Being applied to any external part of the body, they immediately cauſe an itching, ſwelling, pungent pain and inflammation; bliſters eating down into the fleſh, and introducing a cruſty ſcab; all which are the effects of fire it ſelf; like which too, it will afterwards bring on a gangrene, or mortification. I cannot, therefore, give into the opinion of the great M. *Homberg*, who ſuppoſes there is but one ſalt in nature; and that an acid, combined with earth, in different proportions, is the cauſe of all that variety we obſerve in ſalts. For it ſeems no way probable to me, that ſuch a degree of corroſiveneſs, as we find in the fixed ſpecies, ſhould ever proceed from a mixture of earth; eſpecially ſince we find that all the differences, in point of corroſiveneſs, between them are occaſioned, either by taking away what was not ſalt before, I mean their oil; or elſe by the addition or application of fire, which is a thing that appears very different from ſalt. And from hence we learn, that fixed ſalts may be compounded of the oil, native ſalt, and earth of vegetables, united together, by means of fire, or elſe incorporated with it. (7.) It appears that alkaline ſalts are capable of cryſtallization; which is contrary to the opinion of ſome eminent chemiſts. For after we had filtred, and rendered the deliquated oil of our ſalt, to appearance, perfectly pure and tranſparent; yet when it was ſet to reſt in a cool place, it firſt grew thick or turbid, and afterwards ſhot to the bottom a true ſpecies of cryſtalline ſalt. This, indeed, is a ſurprizing phenomenon, and what a man would not readily expect. It ſhould ſeem from hence, as if there were ſuch things as ſeminal principles, or impreſſions, not to be deſtroy'd or alter'd by the power of art. And 'tis very remarkable, what Mr. *Boyle* obſerves of theſe cryſtals, where he admirably treats of the differences of ſalts, that tho' they ſhoot from ſo very ſaline and ſtrong a lixivium, yet of themſelves they are not corroſive; at moſt not ſo violently acrimonious as the ſalt from whence they were obtained. Theſe ſalts, indeed, when only diſſolved in water, do not ſo eaſily afford their cryſtals; but they do it in plen-

plenty, when suffered to run in the open air. Which may proceed from that wonderful property they have, of attracting other bodies, and uniting them with themselves; such as water, oil, air, *&c.* So that these crystals seem to be an alkaline salt impregnated with the salt of the air; which possibly may be of an opposite nature thereto. Thus we find, that by pouring vinegar upon salt of tartar suffer'd to run in the air, we may regenerate tartar, or produce it afresh; and so of the spirit of sea-salt, and the alkali of tartar, we can reproduce sea-salt; with the spirit of nitre, salt-petre; and with oil of vitriol, vitriol itself, bating the loss of its metalline part. (8.) In the last place, we may learn from our preceding processes, that the salts of animals proceed from the food and medicines they make use of. Some are of opinion, that because the parts of our bodies, when they come to be distill'd, yield a copious salt, they must be endowed with a faculty of forming it. But in reality, neither we, nor any other animals are possessed of any such a faculty; and can only change the salts taken in, along with such vegetable substances as are used for food, or physic, but never create, or make any. There is no vegetable substance capable of affording nutriment to the body, but what contains some quantity of salt. An ox, which feeds upon nothing but grass, has a large proportion of saline matter in his blood and urine; and an infant, who sucks nothing but milk, that is sweet to the taste, will still have his juices mixed with salt: which can happen from no other cause than this, that the salt of the vegetable substances, fed upon by animals, is extricated, and set free from the oil, or other parts, by the *vis vitæ* residing in them; and so, mixing with the blood, is suffered to pass off with the excrementitious juices. Only, upon account of the motion and brisk circulation perform'd in animals, these salts are more broke and attenuated than we find them in plants; as we shall make more fully appear, when we come to examine the subjects of the animal kingdom. And this is all we have here to offer upon the subject of vegetable salts.

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# CHEMICAL HISTORY *of* DISTILL'D WATERS.

*Introduction to the hiſtory of diſtill'd waters.* THE order before laid down, requires us next to attend to the phyſical changes which vegetables undergo, by the joint action of fire and water, whilſt they are contained in cloſe veſſels, that catch and condenſe the vapor or exhalations, which would otherwiſe fly off; and ſo preſent us with the inviſible parts they loſe by the treatment of our ſecond and third proceſſes; or whilſt they remain in a ſtate of decoction, under the form of a viſible water. The doing of this we call by the name of *Diſtillation.* We are already inſtructed in the nature of decoction; but are not yet given perfectly to underſtand what its different ſubjects loſe in that operation; or what it is which continually exhales from them in fume, vapor, or ſmoke, whilſt that proceſs is in hand. When we ſhall once be acquainted with this, we ſhall know the whole force of fire upon plants, whilſt it acts through ſuch a medium as water. But the only way of making this diſcovery is by diſtillation; which we define the method of condenſing and collecting the vapors ariſing from boiling ſubjects, ſo as to render them viſible, permanent, and capable of being examin'd by our ſenſes. The parts of vegetables which uſually come over in this manner, are their water, oil and ſalt. But in order to obtain each of them in perfection, and clearly to demonſtrate the juſt effects of fire and water upon the ſubject, it is proper to obſerve this general method. (1.) The inſtrument made uſe of in different diſtillations, ſhould, as much as poſſible, be the ſame alembic, furniſh'd with its proper worm and refrigeratory. By an alembic, otherwiſe called *Veſica*, we mean a veſſel of copper, whereto a concave, globular, or hemiſpherical, metalline head may be cloſely luted or cemented, ſo as to ſtop the riſing vapors, and direct them to the tube which leads from it into the worm. The worm is a long ſpiral tube of lead, running thro' the refrigeratory, to tranſmit the condenſed vapor, and diſcharge it at its lower aperture. The refrigeratory is a large wooden veſſel, filled with cold water; through which the worm takes its courſe from the upper part, towards the lower. Its office is, to cool and condenſe the riſing fumes, and cauſe them to come off in the form of a liquor. (2.) The ſubjects made choice of being put into the alembic abovementioned, a ſufficient quantity of clear water pour'd thereto, and the head luted on, that communicates with the worm; a proper degree of heat is to be applied, to make the liquor boil; whereby there will be obtain'd, in the form of water, whatever that degree of fire cauſes to riſe; which the head keeps in and condenſes, ſo that it runs off through thro' the

the worm. (3.) After this, in order to ſhew how ſuch diſtill'd liquors may be enrich'd and improv'd to the purpoſes of medicine, it will be neceſſary to cohobate them; that is, to pour them back, inſtead of common water, upon more of the ſame kind of ſubject, and diſtil them off again, as before. (4.) And laſtly, it will be convenient to ſhew what changes the ſame degree of fire, applied and directed in the ſame manner, will produce upon the ſame kind of ſubject, after it is fermented; and how its exhalable parts are thereby changed in their nature.

## PROCESS XIV.

### *Exhibiting the common manner of* Diſtilling WATERS *from recent* Vegetables, *by an Example in the plant* Roſemary.

1. P*UT a ſufficient quantity of roſemary, freſh-gathered, in its perfection, and cut moderately ſmall, into a copper alembic, or* veſica, *ſo as, without much preſſing, to poſſeſs about three parts of the body of the ſtill; and then pour rain-water thereon, to an equal height with the plant: after this, lute on the head, with a mixture of linſeed-meal and water, join its roſtrum to the worm of the refrigeratory, lute the juncture, and place a proper receiving veſſel at the lower orifice of the worm. (2.) Let the ſubject thus ſtand in infuſion, with a ſmall degree of heat, for the ſpace of twenty-four hours; then increaſe the fire till the liquor begins to boil; which may be known by a hiſſing noiſe withinſide the alembic, a violent heat perceivable by the hand applied to the top of the ſtill-head, the ſmoking of the refrigeratory, and the drops which will now begin to fall apace from the worm into the receiving veſſel. (3.) Continue the ſame degree of fire, ſo long as any thick, turbid, milky, frothy, odorous and ſapid water will run off; or till a clear, inſipid, ſcentleſs, or acid water begins to come away; and let the former liquor be carefully collected and kept by itſelf, without any mixture of the other; for this alone is the water required of our preſent proceſs.* *The proceſs.*

2. The water put to the ſubject ſhould not fill more than two thirds of the alembic, becauſe it might otherwiſe eaſily riſe ſo high in boiling, as to paſs over the helm, and foul the diſtill'd liquor. The degree of heat employ'd, during the time the plant is infuſed, ought not to exceed that of the human blood in its natural ſtate; which will excellently prepare it for diſtillation; by looſening and reſolving the ſaline and oily parts of the ſubject. After this, the fire muſt not be made too ſtrong at firſt; for in that caſe, a foul frothy matter would be made to riſe and lodge itſelf in the worm; and part of the ſubject going over with the water, would clog the ſame, and render the water impure. *Directions relating to it.*

When a hiſſing noiſe is perceived in the alembic, and the head of the ſtill is grown ſo hot, quite up to the end of its roſtrum, that it cannot well be handled without pain, the water of the refrigeratory will ſmoke, and the liquor begin to diſtil gently; which are ſigns that the ſubject matter is duly agitated by the fire. For if the degree of heat employ'd ſhould fall ſhort of this, the ſubtile, oily, and volatile parts of the plant would not riſe, but remain fix'd in the ſubject, or the infuſion; ſo that only an inſipid and inſignificant water would diſtil off: but if the fire be raiſed too high, the boiling matter will run off too haſtily, in the form of a decoction, and ſo foul the worm, and ſpoil the water. With this due degree of heat, therefore, we are to proceed, till all the water of any virtue is drawn off; or till an inſipid, tranſparent, or acid kind of liquor begins to run; from which the other muſt, by all means, be ſeparated, becauſe it would, by reaſon of its acidity, give a tart taſte to the water, and by corrupting the oil thereof, ſoon turn it rancid, and render it unfit for keeping; or elſe it would communicate a vomitive quality thereto: for being enabled, by the acid it contains, to work upon the copper of the ſtill, it impregnates itſelf therewith, and ſo becomes emetic. Thus, I once remember, that having preſcribed ſome cinnamon-water to an infant, contrary to my expectation, it cauſed her to vomit. Upon which, being preſently called again, I examin'd the water, and found it of a greeniſh colour; from whence I conjectured, that the diſtillation of it having been too long continued, the liquor of the laſt running had corroded the copper head of the ſtill, carried off ſome particles of the metal, and copiouſly mixed itſelf with that which firſt come away pure and perfect. At another time too, upon the ſame account, I ſaw a perſon thrown into convulſions by the uſe of a little mint-water. Whence we ſee what great miſchiefs may be occaſioned by ignorance, neglect, or ſavingneſs in the buſineſs of diſtillation. But in caſe ſuch a hurtful diſtill'd liquor ſhould at any time be uſed, inſtead of that which is pure and genuine, and a vomiting, or diarrhœa be excited by it, the proper remedy is to drink down large draughts of milk, or hydomel, or plentifully to inject the ſame liquors by way of glyſter. If the diſtillation, therefore, be continued too long, the water will be impure; and if not carried on till all the odorous, thick, and milky part is obtained, it will not be perfect, or contain all the virtues of the plant, which ought to be gain'd from it by the operation; the deſign whereof is to give us a water, endued with the perfect ſmell and taſte, or native oil of the plant, attenuated ſo as to riſe in vapor by heat, and be condenſed by cold into a liquor, which is always the richer and ſtronger, as it contains the more of that oil. And this is the common method practiſed by apothecaries, and others, in drawing off all their diſtill'd waters.

3. The

3. The vegetables beſt fitted for this proceſs are the ſapid and odorous, or ſuch aromatic plants as were ſet down in our catalogue under the firſt proceſs; and which, by the ſeveral proceſſes we have gone through, appear to contain a large proportion of ſaline and oleaginous matter, or a ſubſtance that is ſaponaceous; the oily portion being of three kinds, *viz.* that which riſes in the water of the firſt proceſs; that which remains behind in the decoction; and that ſtrong, glutinous ſubſtance which obſtinately adheres to the remaining matter. All theſe vegetable ſubjects ſhould be gathered for diſtillation in their prime, or whilſt they are in the leaf, before they put out their flowers, or run to ſeed; unleſs we deſign to make uſe of the ſeed or flowers themſelves. For 'tis a general rule, that plants loſe thus of their virtue, eſpecially of their aromatic parts, and ſpend themſelves in their flowers and ſeed; at which time they therefore conſtantly appear to droop and languiſh. But whenever the flowers and ſeeds of vegetables are more odoriferous and aromatic than their leaves, we are to make choice of the latter for diſtillation; and theſe too ſhould be gathered whilſt they are in perfection. Thus, to gain the medicinal water of roſes, or lavender, gather not the leaves, but the flowers of thoſe reſpective vegetables, in their ſeaſon, and commit them to diſtillation: but the ſeeds of ſome plants are to be preferr'd for the ſame purpoſe, as aniſeed, for inſtance. In ſhort, ſuch vegetables, or ſuch parts of them ſhould always be choſen for this proceſs, as are moſt aromatic, and abound moſt in oil; in which the virtues of theſe diſtill'd waters principally reſide. And, therefore, thoſe ſubjects which afford little or no native or eſſential oil, by diſtillation, are improperly treated by it. Thus it would be abſurd to diſtil the *Peruvian* bark, in order to obtain a water therefrom, endowed with its febrifuge virtue, which does not reſide in the eſſential oil of that vegetable *. *The ſubjects beſt fitted for it.*

4. Hence we learn, (1.) What it is that aſcends, in form of vapor, from an aromatic plant, by the heat of boiling water; *viz.* the water of our firſt proceſs, the oil, natural acid, and volatile ſalt of the ſubject. (2.) What remains behind, after ſuch an operation; *viz.* the decoction of our ſecond, or the extract of our third proceſs, or a mixture of the leſs volatile oil, and acid ſalt of the plant, diluted with water, together with the remains of thoſe proceſſes. (3.) What is the cauſe of the particular taſte and ſmell of the plant, and in what part thereof it re- *The inſtruction it affords.*

* The whole art of pharmacy conſiſts in treating the *materia chemica* in a manner ſuitable to every ſubject; ſo as to gain from it the parts and virtues we want, unimpair'd, and reduced to a form convenient for taking, and keeping, at all times, ready for uſe. We muſt of neceſſity be previouſly acquainted with the natures of vegetable, animal and mineral productions, and their ſeveral parts; have a knowledge of menſtruums, their properties and uſes; and underſtand the effects of phyſical agents on them, with the manner wherein that action is perform'd, before we undertake to write pharmacopœias, or even extemporaneous preſcriptions. 'Tis a jeſt to ſet about either, before we are maſters of ſo much knowledge; and by ſo doing, ſhall only expoſe ourſelves to the laughter of ſuch as are judges in this way.

ſides; *viz.* in its eſſential oil, or the water of our firſt proceſs, wherein that oil appears to be greatly attenuated and exalted. (4.) What it is that exhales or flies off into the air in preparing decoctions; *viz.* the odoriferous ſpirit, or oil and water of our firſt proceſs, with ſome portion of the eſſential, or native acid ſalt; the matter of the thick pitchy oil, or fix'd ſalt, and earth remaining behind. (5.) That at different diſtances of time, from the beginning of diſtillation, there run off waters of contrary properties and virtues. Thus, the firſt running is commonly aromatic, cardiac, and heating; but the ſecond refrigerating and tart, after it has done running milky. And this is moſt highly remarkable in the diſtillation of *Indian* cloves. (6.) And, laſtly, we learn from this proceſs, how diſtillation is to be applied, regulated and directed, for the theoretical and practical uſes both of chemiſtry and medicine.

*Its uſe in medicine,*

5. The medicinal virtues of waters prepared after this manner, are the ſame with thoſe of the reſpective plants, from which they were drawn. Thus the diſtill'd water of mint is ſtomachic, that of wormwood, vermifugous, &c. for which we refer to the botanic writers; ſuch as *Dioſcorides*, *Dodonæus*, *Ray*, &c. 'Tis obſerved by the Sieur *Rhedi*, in his experiments upon worms and inſects, that the diſtill'd water of ſuccory has the power to deſtroy them; which is more than either the expreſſed juice or decoction of that plant can effect. And, in reality, this virtue can only be attributed to the water of the laſt running in the diſtillation of ſuccory, which, by reaſon of its acidity, frets and corrodes away ſome particles of the copper veſſel in the operation, that give it the faculty. And the longer this latter part of the diſtillation is continued, the more acid the liquor grows; and conſequently the better able to impregnate itſelf with the particles of the copper; ſo that at length it will, by this means, become highly emetic, and capable of ſuddenly deſtroying all manner of worms and inſects. Whence we ſee, that in the caſe of ſuccory-water, it is not the vegetable, but the metal, which is of force againſt worms. For the plant of itſelf has no ſuch virtue, till its native ſalts are made to riſe in diſtillation, and waſh off or diſſolve ſome particles of the copper.

## PROCESS XV.

*Exhibiting the manner of* Cohobating WATERS *distill'd* per vesicam, *from recent vegetables; by an example in the water of the foregoing* PROCESS.

1. *STRAIN off and press out the decoction of the plant, which remains after the preceding process is ended; and, pour it, together with all the pure aromatic water that was distilled over, without any mixture of the acid part which comes at last, upon fresh rosemary; so that the decoction, and the distill'd water, may together serve instead of a like quantity of common water. Then let them stand together in the alembic, with a moderate heat, for the space of three days and nights; and proceed in all other respects, after the manner of the fourteenth process; only let the fire be a little gentler than before.* *The process.*

2. The preceding process informed us what it is which the joint action of fire and water raises from vegetables by decoction, in close vessels, and what parts of them it leaves behind; and the present shews us a method of opening the bodies of plants to greater advantage, so that the waters they afford by distillation, shall be stronger, and more efficacious. This method we call by the *Arabic* name of *Cohobation*, which, as we before observ'd, signifies that kind of distillation, wherein, instead of common water, distill'd-water of the same recent plant is return'd upon a fresh subject, and the distillation repeated, in order to bring over a water that shall be more fully impregnated with the oily parts of the plant. *Its nature.*

3. The water thus drawn off, will at first be as white as milk, and have a large quantity of oil swimming upon its surface. 'Twill most distinctly, and in great perfection, possess the smell and taste of the plant, appear thicker, more frothy, and in all respects much richer, and more efficacious than the water of the preceding process; and the oftner the cohobation is repeated, the more unctuous and noble it becomes. 'Tis its large quantity of oil that makes it appear so white; and therefore the whiter it is, the richer and better it must prove. By a number of successive cohobations, it will be so impregnated with oil, as to appear like a thick emulsion, or an *elæosaccharum*, as to its consistence. If this water be permitted to stand at rest for some time, it commonly drinks into itself, or takes up that from the oil, which gives the plant its peculiar scent and odour; whereupon the remaining oil becomes a light kind of mucilage, or soft wax. That which runs second, will contain but a small proportion of oil, tho' 'tis still richer than the first running in the *Nature of the production.*

the preceding proceſs. But that which comes off towards the end of the operation, will be perfectly ſimple and tranſparent; except that its taſte may prove ſomewhat ſharp or acid.

*Reaſons for the direction of the proceſs.*

4. The decoction of the preceding proceſs, as well as the water of it, is here poured back upon the freſh ſubject, becauſe being of a ſaponaceous nature, or conſiſting of a mixture of ſalt and oil, it greatly opens the vegetables wherewith 'tis boiled, and ſets their principles free. And bodies are never better diſſolved, than by menſtruums analogous to themſelves. We order the ſubject to ſtand in infuſion for three days and nights, before the diſtillation is begun, and with ſuch a gentle heat, as will, by no means, cauſe the liquor to boil; but if it were to ſtand in this ſtate much longer, it might begin to putrefy, and ſo become unfit for our purpoſe. 'Tis the deſign of thus infuſing our ſubject, to ſeparate its more volatile parts from thoſe that are more fixed; and ſince by ſuch a method we excellently obtain that end, the operation is called *chemical digeſtion.*

*How performable to beſt advantage.*

5. When the vegetable ſubjects deſign'd for this proceſs, are very oleaginous, aromatic, and hot, they ought firſt to be gently dried in the ſhade; then, being cut, and mix'd with thrice their own quantity of water, let them be ſuffered to macerate with a ſmall heat, for the ſpace of four days, in a cloſe veſſel, before they are committed to the ſtill: and if roſemary, mint, baulm, marjoram, origanum, ſage, penny-royal, hyſſop, ſavin, orange-peel, citron-peel, or any other vegetables which contain any quantity of balſam, be thus treated, they will afford moſt admirable waters. But thoſe plants, whoſe odoriferous or medicinal parts ſoon ſpend themſelves in exhalation, ſhould be thrown into the alembic, as ſoon as they are gathered, and be diſtill'd off immediately, without any previous digeſtion. And thus violets, borrage-flowers, lilies, roſes, jaſmin-flowers, &c. afford delightful, fragrant waters; their fragancy conſiſting in a ſubtile ſpirit, and not in a viſcous oil; which is the reaſon of its being ſo ſoon loſt. When waters are to be diſtill'd from any kind of fragrant barks, or woods of a cloſe texture, and a ſolid nature, they ought to be firſt ſhaved thin, and put to ſteep in water, made ſaline with a moderate quantity of ſea-ſalt, and to be kept the longer in maceration, as their cloſeneſs is the greater, or as they are more reſinous, ponderous, and durable. Thus the woods which ſink in water, as box, guaiacum, rhodium, *&c.* ought to be ſteep'd, for the ſpace of three or four weeks, before they are diſtill'd for their eſſential oils: during which time, the ſalt-water inſinuates itſelf into, and by its attenuating quality, opens the bodies of them, keeps them ſweet, and preſerves them from corruption. But the lighter woods, as ſaſſafras, for inſtance, are not to be treated in this manner; becauſe the oil of them is ſubtile, and exhalable, and they afford a very ſtrong ſcent, with a ſmall degree of heat. The aſtringent, nutrimental, laxative, emollient, gelatinous, ſtyptic, and

and coagulating virtues of vegetables are never to be expected in the distill'd waters of them; but in their decoctions, extracts, or express'd juices. This rule, well observ'd, would ease the apothecaries of a deal of trouble. Simple plantain water, and small cinnamon-water have just as much virtue, in case of a *diarrhœa*, as that which falls from the clouds. Who can help laughing to see pearls ordered for distillation, as they are in the royal pharmacopœa of *Germany?* Some think they enrich their waters by throwing leaf-gold into the still along with the other ingredients; but this is the way to impoverish the patient sooner than raise his drooping spirits. To use tormentil-water, as a styptic, is doing nothing for the good of the patient; and, in short, to distil any manner of subjects, in order to obtain such parts of them as will not rise by decoction, is trifling with the world, and amusing our selves; and therefore, all things of this kind ought to be expunged the art of physic *. There is, however, another species of cohobation, different from that abovementioned, by means whereof perhaps a few of the more fixed parts of vegetable substances might possibly be obtained upon distillation; *viz.* by pouring back all that runs off upon what remains behind, at the same time that another fresh portion of the subject is also put in. And by this means a saturated water, or oil, may be gained from the *lignum sanctum*: but they are only the aqueous, spirituous, or finer oleaginous parts that can well be brought over even in this manner; the rest must remain behind in the decoction; which may, as we formerly saw, be boiled up to an extract. Whenever therefore the virtues of plants reside in these lighter parts, they may be distilled to advantage for medicinal uses; otherwise they ought rather to be given in the form of a decoction, or extract. Thus, in case of the epilepsy we ought to give the water of lavender, and not its extract: but the decoction, or extract of cinnamon, should be taken for a *diarrhœa*, and not its distill'd water, which contains nothing of the astringent or earthy part of the bark. The advantage therefore of such distilled waters is, that they contain the specific scent and taste of the plant, or the essential oil thereof, in a great degree of perfection, separated from its other principles. But some plants are possessed as well of a fixed part that is medicinal, as this volatile one; in such cases therefore, the distill'd waters should be mixed with the decoction, or extract; by which means, all that is specific in the plant would be got together in a form proper for exhibition. This is the case of wormwood, southernwood, mugwort, carduus, centory, tansey, camomile, elder-flowers, juniper-berries, &c. the extracts, or decoctions whereof prove

* I know not whether a man would be more dispos'd to laugh, or rave, upon examining the most famous and approved dispensatories in *Europe*, with this key, to see how many errors of the like kind are committed in them. The ignorance of the compilers may indeed be laugh'd at; but the condition of the poor patient, for whose service these labours were design'd, cannot fail to move our pity.

excel-

excellent, as well as their diſtill'd waters; which alſo may be greatly improved by fermenting the ſubjects before they are committed to diſtillation: but then their extracts are the worſe for it. But that which is the cauſe of the native taſte of the plant does not riſe ſo eaſily, except when the plant is very aromatic; in other caſes 'tis apt to remain in the decoction; eſpecially when the ſubject is ſweet, auſtere, acid or bitter. Wormwood, however, and camomile, by the force of cohobation, will yield a water of their own peculiar bitter taſtes. Hence we ſee there muſt be a very great number of vegetables abſolutely unfit for diſtillation; as not affording their particular virtues to the waters drawn from them. Such are ſorrel, wood-ſorrel, barberries, cherries, mulberries, ſtrawberries, apples, ladies-mantle, currants, red and white, but not the black, which afford an excellent water; borage, ſuccory, endive, plantain, cinquefoil, nightſhade, ſow-thiſtle, violets, lettice, tormentil, purſlain; and many of the plants enumerated in the catalogue under our ſecond proceſs, whoſe virtues are great in their extracts, but afford only an inſipid water by diſtillation. But when we have an aromatic plant, whoſe virtues conſiſt in its volatile oil, then our preſent proceſs will give us them concentrated, as the chemiſts ſpeak, or reduced into a narrower compaſs, and made greater than they were in the plant it ſelf. Whence theſe cohobated waters are highly uſeful in the practice of phyſic.

*Its uſe in medicine.*

6. Thus by the repeated cohobation of mint-water, we may obtain, from the vegetable claſs, the moſt excellent remedy for vomiting, that I am acquainted with, except it be opium; as likewiſe in all hyſterical caſes, or where the matter of the gout is ſtruck inwards upon the viſcera; being taken in the quantity of half an ounce: which doſe ſhould be repeated once an hour till the cure is effected. *Sydenham* aſſures us that the ſame water is an admirable remedy in the *cholera morbus*; and, indeed, when thrice cohobated, 'tis almoſt infallible in that caſe. The diſtill'd water of baulm, cohobated in the ſame manner, gives great relief to hyſteric women, and hypochondriacal or ſtudious men, in fits of depreſſion, or palpitation of the heart; and is one of the beſt medicines we have, when thoſe caſes happen in weakly conſtitutions, as they commonly do. Thus likewiſe the diſtill'd water of citron-peel is a wonderful remedy in fainting fits, or where a ſharp alkali is ſuſpected, as in the meaſles, ſmall-pox, peripneumonia, &c. and might, I believe, be very ſafely enployed in peſtilential caſes. Savin-water is an excellent emmenagogue, and may, when the body is rightly prepared for it prove a ſpecific, if the cauſe be only the want of a ſtimulus. By preparation, I mean no more than that the patient ſhou'd firſt go into a warm bath, and after he comes out, take an ounce of this water; repeating the doſe four or five times a day, as there ſhall be occaſion. Camomile-flower water is, according to *Pitcarn*, a powerful medicine for tertian or quartan agues; and as well as the diſtilled and cohobated waters of wormwood,

and

and tansey hath the faculty of destroying worms in the human body, and bringing them away. Wormwood-water also is very beneficial to weak stomachs, it promotes digestion, and helps in colical cases; proceeding from a cold cause. And thus, by distillation and cohobation, we may gain other waters, of great virtue, from vegetables, and fit for several medicinal uses.

## PROCESS XVI.

### *Exhibiting the manner of* DISTILLING *the* WATERS *of fermented* Vegetables, per vesicam, *according to the practice of* Ludovicus; *by an example in* ROSEMARY.

1. TAKE *rosemary, or any other aromatic, recent, succulent plant, gather'd in its prime; cut it into small pieces, or bruise it; pour thereon twelve times its own quantity of warm rain-water, and add about a fiftieth part of yeast; or an eighth of sugar or honey, in respect of the water; let all be put into a vessel of oak, placed near a fire, if it be winter, and well covered with clothes to keep the liquor warm, for the space of six or seven days; during which time there will arise an intestine motion, attended with a hissing noise, and a frothing on the surface, which will throw up the plant, and sustain it at the top: and this particular motion we usually call by the name of* fermentation. (2.) *When the operation has been continued its due time, the plant, which floated on the top, will fall to the bottom of the liquor; the hissing noise will cease, the froth subside, and the liquor, which before lay under it, appear, and send out a fragrant vinous odour: and now the plant is sufficiently opened to afford its virtues, or spirit in distillation.* (3.) *Commit the whole, therefore, to the alembic, and proceed to distil off the liquor, in the manner, and with all the cautions observed in the fourteenth process; being here more careful as to the regulation of the fire, because the matter in the still is more apt to boil over, than in the former cases.* (4.) *The phænomena of the liquor that thus runs off will vary with the degree of fermentation undergone by the subject. If the operation was perfectly performed, with a considerable proportion of honey, sugar, or yeast, there will come over a thin, limpid, fragrant, inflammable spirit, without any apparent mixture of oil; but if only a small quantity of yeast, sugar, or the like, was employed, and the fermentation was not continued too long, or raised to any great height, then a very white, thick, fat, frothy, odorous, sapid and penetrating water will be obtained, with a small proportion of a thin oil swimming on the top thereof. And this is the water intended by the present process.* *The process.*

2. In the first case, after the limpid spirit is run off, there will follow a white, milky, thick, fragrant water; and in the second, a thin, limpid, acid, ill-scented and refrigerating liquor comes away at last. After which, if the fire be increased, a kind of vinegar follows. But *It's effects farther continued.*

when the fermentation has been long continued, tho' not till all the oil of the plant is entirely converted into ſpirit; the laſt running will be a mere inſipid, or ſub-acid liquor. If the fermentation ſhould be long continued, or perfectly finiſhed, and the clear liquor be committed to a proper wooden veſſel, cloſe ſtopp'd up, it would in a little time become very tranſparent and fine; and being now diſtilled, afford a ſharper liquor, or inflammable ſpirit, without the leaſt ſigns of oil: but it would retain nothing of the taſte, ſmell, or ſpecific virtues of the roſemary; ſo that it cou'd not be told by examination what the plant that afforded it was. We muſt obſerve, in the management of the fermentation, to proportion the degree of heat, and the quantity of the yeaſt or ſugar, *&c.* to the ſeaſon of the year, and the nature of the climate. The hotter the ſeaſon or climate, the leſs yeaſt will the liquor require; and the ſooner will the operation be performed. The whole proceſs would, in *Aſia*, be finiſhed in the compaſs of two days. But the caſe above-deſcrib'd is to be underſtood of the winter ſeaſon, and a northern climate; where fermentation proceeds ſo ſlowly, that we are obliged to promote it by artificial heat; which, however, ought not to exceed that of the ſummer's ſun with us. We are not tied down to the uſe of yeaſt, ſugar, or honey, in this proceſs; but *muſt*, or new wine, beer, the juice of caſia, manna, and ſeveral other things will ſerve to raiſe a fermentation, as well as thoſe. When the plant ſubſides, or ſinks to the bottom of the veſſel, 'tis a ſign that the fermentation is finiſhed, or has been continued long enough for our purpoſe; for whilſt the ſubject was kept afloat, the inteſtine motion continued ſtrong, and the air, which is a principal cauſe of fermentation, was not yet ſufficiently extricated from the plant; but when it ſinks, 'tis a ſign that the air-veſſels of it are broke, and the contents of them ſet free: whence the oil, which was before locked up in theſe cells, is now diſperſed thro' the whole body of the liquor; at which time therefore the fermentation ought to be ſtopped, and not ſuffered to renew again; for in that caſe the ſpirituous parts being now ſet looſe, wou'd fly away, and leave the remaining liquor, vapid, flat and dead. If it could be conveniently done, one wou'd chuſe to ferment the ſubject with water alone; but we here require the aſſiſtance of ſome foreign body; becauſe the plant it ſelf affords but a light, or thin infuſion, which of it ſelf will never ferment kindly. Very thin liquors always require ſome glutinous or viſcous ſubſtance, to forward and promote their fermentation: but in what manner this is effected we ſhall explain hereafter, when we come to give the full hiſtory of that grand operation. The oil of any ſubject totally vaniſhes after it has undergone a perfect fermentation; being by that operation ſubtilized, broke fine, and exalted into a ſpirit. Thus in the ſecond caſe of the preſent proceſs, the groſs high-coloured oil of our fourteenth and fifteenth proceſſes, is greatly thin'd, diluted, and brought nearer to the nature of a ſpirit; ſo as in ſome meaſure to unite

with

with water: but in the first case 'tis wholly converted into a spirit, capable of uniting with water. For when ever the native or essential oils of crude plants are so attenuated by fermentation, as thus to mix with water, then it is that they lose the name of oils, and assume that of spirits. The extract prepared from the remaining decoction of this process, contains much less of the virtues of the plant, than the remains of the two preceding processes; whence we may form this rule, that the more a vegetable is fermented, the stronger or more spirituous will be its distill'd water, and the less the virtues that afterwards remain in the decoction: for fermentation always dissolves and considerably loosens some parts from the subject.

3. Hence we learn, (1.) That the specific taste and scent of plants, communicated to their distilled waters, depend upon the oil of the respective subjects. (2.) That by fermentation, as well as a long continued coction, and repeated cohobation, the oils of vegetables come nearer to the nature of spirits; or are thereby rendered easier to mix with water. (3.) That the finer the oils of vegetables are broke by repeated operations, the more they lose of that specific principle which distinguishes them from one another. (4.) And lastly, that fermentation has a great power to alter vegetable subjects, so as to render them capable of affording waters of wonderful properties, and very different from those they were before possessed of. *The chemical doctrine it affords.*

4. The medicinal virtues and uses of distill'd waters, prepared after the manner of our present process, are very considerable. For, (1.) They contain the oil of the plant in great perfection; so that the specific virtues of aromatic vegetables may hence be obtained to advantage. (2.) They are very well suited to carry the essential oils of plants into the blood and juices, and to mix them therewith: they also act powerfully upon the coats of the œsophagus, stomach and intestines. Thus the distill'd water of fermented orange-peel, for instance, might be given, as a stomachic and cordial, with all the advantages that a physician cou'd desire. And (3.) These waters are much better fitted for keeping than those of the fourteenth and fifteenth processes, and will long continue good and perfect; because the spirit in them prevents their corrupting or growing mothery; so that when kept in a well closed vessel, the oil will rise to the top, whence they lose their milky colour, become perfectly transparent, and improve in their virtues. Cohobated waters may, indeed, be kept tolerably good, for almost the space of two years; tho' they are apt to grow mothery or ropy in that time; but those prepared by fermentation will continue unaltered, and in their full virtue, for six or eight years together. *Medicinal virtues and uses of its productions.*

## PROCESS XVII.

*Exhibiting the manner of* distilling WATERS *from* VEGETABLES per descensum, *by an example in* ROSEMARY.

*The process.* 1. *PUT rosemary, or any other recent, succulent plant, capable of affording an extract, or a distilled water to advantage, into a linen cloth fixed round the brims of some proper vessel, that is made deep and large; or into a hollow metalline plate, perforated in several places, and fixed in the same manner to the edge of the vessel; which is to be closed with a metalline cover made for the purpose, so that no vapor may exhale at the juncture.* (2.) *Let a moderate charcoal-fire be kindled upon the cover, which, being made hot thereby, will liquify and dissolve the more moveable parts of the subject, and cause them to descend, partly in the form of vapor, and partly in that of drops, to the bottom of the vessel, whose office it is to receive the liquor thus made to descend.*

*The cautions it requires.* 2. Care must be had not to make the fire too strong; lest it should greatly mix and confound the parts of the subject among one another, or render the water empyreumatical. This may be easily prevented by keeping the fire covered up with its own ashes. The deeper the vessel which is made use of in this operation, the cooler the season wherein it is performed, and the less the fire at first employ'd therein, provided it be afterwards raised by gentle degrees, in the greater perfection will this water be obtained.

*It's effects.* 3. As the more moveable or volatile parts of vegetables are the aqueous, gummy, resinous and saline, these are what we must expect in the water of this process; the heat employed being so great as to burst the vessels of the subject: but some plants contain so large a proportion of oil, that this will sometimes be found swimming on the surface of the water.

*It's uses.* 4, We see, therefore, that the waters of this process will nearly afford us all the native virtues of the plants submitted to it; or a mixture of their several parts: whence they, in a manner, come up to the express'd juices, or extracts gained from them. But as only a small quantity of water can be obtained by this operation, a mixture of the distill'd waters of our first, fourteenth, fifteenth, or sixteenth, processes, with the decoctions of our third, may be exhibited with greater convenience, and to equal advantage. *Paracelsus*, however, highly commends the water of guaiacum, prepared after this manner, in venereal cases; and perhaps it might prove a powerful sudorific; but the medi-

medicine must needs be very nauseous, strong, and disagreeable. 'Twas possibly this recommendation of *Paracelsus*, that occasioned this kind of distillation to be so frequently practised in *Germany*.

## PROCESS XVIII.

*Performed upon the* REMAINS *of the four preceding processes; by reducing them to ashes.*

1. *TAKE all that remains in the still after any of the four preceding processes are finished, dry the plant, exhale away the decoction, and at length reduce them to ashes by an open fire, in an iron vessel, after the manner formerly described; and these ashes will be found as saline, as those obtained by our fifth and sixth processes; only they will not prove quite so strong as if the subjects had never been distilled; and greater allowance must be made for those afforded by the remains of that subject which had been fermented.* *The process.*

2. Whence we see what it is that ascends in preparing decoctions, and performing of distillation; and what it is which remains behind after those operations are finished. The native spirit, essential oil and water, with a small proportion of the native salt of the plant, are all the parts that rise in decoction, or distillation; the more fixed oil, and salt, with the whole quantity of earth remaining behind. *It's use.*

# CHEMICAL HISTORY *of VEGETABLE OILS.*

1. A Vegetable oil is that moist, fat, viscous, inflammable part of a plant, which is either naturally liquid, or grows thin with a small degree of heat, but will not mix with water. We call it moist, because it wets or sticks to the fingers of such as handle it; fat, because it is very soft and slippery to the touch; viscous, because its parts when united, adhere together, and obstinately stick to the bodies they touch, which no other part of a plant will do; inflammable, because it will flame away, and be wholly consumed in the fire: lastly, we say, it will not mix with water, because whenever it is so mixed, it is no longer oil, but an unctuous, or oily matter; and this property distinguishes it from spirit, which is an oil so subtilized as readily to mix with water. *Introduction to the history of vegetable oils.*

2. In this part of vegetables resides that matter, which being generally the cause of their taste and scent, so effectually determines the particu-

ticular nature of each; tho' it must be allowed, that in some very tart vegetables the oil is insipid. Otherwise when this liquor is extracted from vegetables, the remaining parts lose all their smell and taste. Thus when cinnamon or cloves are deprived of all their oil, we can only distinguish them by their figure from other woody substances, or from one another. We may therefore conclude, that the distinguishing, sapid, and odorous principle of vegetables generally resides in their oil. But we do not assert the oil itself to be this principle; that being no more than the bare vehicle of the spirit which constitutes it. This oil is otherwise called by the name of sulphur; whence some chemists have said, that the sulphur of plants is the seat of their spirit.

3. This oil is often separately contained in the peculiar vessels or cells of plants, call'd by *Malpighi loculi terebinthinacei*, which are to them what the adipous membrane is to us; or otherwise it is intimately mixed with their saponaceous juices. Pure oils of the former kind are frequently found, under the form of gums, rosins, or balsams, lodg'd in the bark and seeds of plants; that is, in their more durable parts; and those which lye most remote from the roots, or aqueous juices. They sometimes, indeed, may be found in other parts, but never in any considerable quantity. Thus if a piece of master-wort-root, for instance, be cut and examined with a microscope, we shall find the oil distilling from distinct cells of the root; but the same may better be observed in a nutmeg, walnut, almond, *&c.* when their parts are separated with a hot knife. The bark of a tree, as well as the seed, must be esteemed a part remote from the roots, because the nutrimental moisture appears principally to enter the woody parts of the tree, as if they were arteries; and to return by the bark, as if that consisted of veins. Hence, when the bark of a tree is cut, its oily cells are visible to the naked eye, or at least may be discovered by the microscope; as particularly in the pine-tree, the walnut, *&c.* and when wounded, it sometimes distils its oil in the form of a gum, as that of the cherry-tree; or in a more fluid form, as in the turpentine-tree. At other times the oil will flow spontaneously from the tree: that is, when too great a quantity is lodged therein, it breaks its way thro' the bark; and in the same manner some seeds and fruits will also burst and discharge their oil.

4. These oils are always to be found in the greatest plenty, when the plant is at its full growth, at the time its sleeps, as it were, or when it is grown old. When a plant is young, it contains only a watery juice. Thus flax, soon after it is first sown, rises in the form of grass, and is altogether as aqueous; but when come to maturity, its seed abounds in oil, of which it contains, perhaps, a larger quantity than all the other parts of the plant. And so likewise young pines, fir-trees, *&c.* afford no turpentine; being, as yet, of too aqueous a nature. A vegetable is said to sleep during the winter-season, when it has lost its leaves; and to be

be awake and lively in the summer. During the time of their rest, a quantity of oil is laid up in them for their defence against the cold; and in proportion to the degree of it which they are to sustain. Whence it is, that the trees of northern climates so much abound with oil. If a tree in this season be deprived of its oil, it presently perishes; and therefore when it comes on, the pines, the firs, *&c.* contract themselves, shut themselves up, and distil no more of their oil; but keep it as a defence from the injuries of the weather. For oil, being incapable of congealing into ice, is excellently fitted for this purpose. And hence we see that those trees which contain it in the greatest plenty, are evergreens. A tree is said to grow old, when 'tis clogg'd and choak'd up by its own oil. Thus we constantly observe that the oldest trees, as pines, firs, *&c.* are suffocated by their own fat or turpentine, wherewith their bark is so stuffed, that the juices can no longer circulate, nor respiration be continued in them; at which time, therefore, they must necessarily dye, as an old man does when suffocated with his own phlegm. And in this manner I have my self seen old fir-trees perfectly choak'd by the large quantity of oil or pitch that was block'd up in their bark.

5. From hence we may learn, that vegetables contain the greatest quantity of oil when they least abound in salt, when the seed is fully ripe, when the flowers are gone, and the leaves fallen off. Hence skilful architects constantly order their timber to be cut in the winter season; as proving then most durable, and free from the worm. For all wood is durable according to the proportion of the oil or rosin it contains. Thus guaiacum, and the red-wood used for cabinets, will endure for many ages. But when we would gather vegetables for the sake of their salt, we must take them in the spring season, before they bear fruit; for during the autumn, the salt, with the other juices, falls down into the roots; so that a pound of the wood of the lime-tree, or vine-cuttings, taken and burnt to ashes in the month of *October*, will not yield so much salt by a third part, as the same quantity wou'd do in the month of *April*.

## PROCESS XIX.

### *Exhibiting the manner of obtaining the* native OILS *of* vegetables *by* expression, *in the treatment of* Sweet-Almonds.

1. T*AKE sweet-almonds, or any other kind of ripe nuts, or seeds, that have been gently dry'd in the shade, and grind them, together with their skins, into a kind of paste or powder; which, being first exposed, for some time to the free vapor of hot water, is to be put into strong linen bags, or strainers, and so placed between two warm iron plates, and committed to a strong press,* *The process.*

*which*

*which being gradually screwed tight, the oil will run from the subject, such as it originally praexisted therein.*

*How performable to advantage.* 2. The subjects of this process should be fully ripe, at which time they are most unctuous; otherwise a saline matter might predominate in the oil: and 'tis necessary to dry them, or by stopping up the stalk, to hinder the water from rising into them from the earth; or else they would afford an emulsion instead of an oil. The vapor of the water, whereto they are ordered to be exposed, serves to open the body of them, resolve the oil, and free it from its cells. The heating of the iron plates conduces to the same purpose: but care must be had that they are not made too hot; for in that case they would give an empyreumatical taste and smell to the oil; which is very disagreeable, and ought by all means to be avoided. And if these cautions are duly observed, a native oil may be expressed from any kind of nuts or seeds, or other parts of vegetables, tho' they appear ever so dry or destitute of oily matter.

*The Nature of the production.* 3. The oils, thus fresh expressed, retain in some measure the nature of the vegetables; from whence they were obtain'd; but contain only a small proportion of the native salt and spirit of the plant; whence some of them appear much of the same general nature. Thus the expressed oil of mustard-seed is sweet and mild, and does not differ greatly from the expressed oil of olives: whereas, that gain'd from it by distillation, being thereby mix'd with the salts, is very pungent, acrimonious and aperitive. But all of them upon being long kept, grow rancid, lose their mild and gentle nature, and become exceeding sharp, corrosive, inflammatory, caustic and poisonous. Thus if the oil of our present process, that of sweet-almonds, were to stand in a hot place, or in the open air, for a fortnight or three weeks in the summer-season, it wou'd have a very pungent, nauseous taste, and if drank, occasion violent inflammatory disorders; for it is then as great a caustic as euphorbium itself *. And this may be the reason why the bile in animals, which is an unctuous humor, when too long detain'd becomes so sharp and corrosive, as to occasion terrible disorders. Whenever, therefore, a physician prescribes the use of expressed oils, let him be careful to order that they be fresh-drawn. The fat of a human body appears to consist of such oil as that of this process; and what is very surprizing, seems to be readily made from vegetables, which contain but very little of it. Pasture-grass affords the least quantity of oil of any vegetable we know; yet oxen, by feeding upon this alone, will turn almost wholly into fat and oil. Whence we have but little reason

* Apothecaries cannnot be too careful in the choice of the express'd oils, so frequently prescribed in pleuritic and other inflammatory cases: the ill success so often met with in such distempers may sometimes be owing to a neglect herein.

to expect the cure of an unwieldly fatness in the body, from the use of a lean diet; or from any thing else but fasting, labour, and sorrow of the mind; tho' sea-salt, sal-ammoniac, vinegar, sugar, and the like resolvents, are allow'd to be serviceable therein.

4. The medicinal virtues of vegetable oils, thus fresh express'd, are lenient, relaxing, anodyne and balsamic. For, having no acrimony of their own, they abate the force of it in the body, relax the fibres, make them flexible and pliant, open obstructions, smooth the passages, heal up wounds, cause dry scabs and eschars to fall off, &c. *Hippocrates*, in case of violent pain, recommends a draught of such express'd oils, with water. Thus the oil of sweet-almonds, when externally applied, assuages the violent pain of any part that has been over-stretch'd; and if rubbed upon a musical string, would suffer it to be stretched out longer, than it otherwise could, without breaking. So likewise when the skin is besmear'd therewith in the small-pox, or a burning fever, 'tis of very great service in relaxing the pores. The same medicine proves excellent also in all spasmodic and inflammatory cases, as the quinsy, pleurisy, convulsions, &c. Fresh-drawn linseed oil is greatly commended in fits of the colic, inflammation of the lungs, and pains of the stomach and kidneys; and the expressed oil of mustard-seed in all cases of the stone; being taken in the quantity of an ounce or two, as there is occasion. *Its medicinal virtues.*

## PROCESS XX.

### *Exhibiting the manner of obtaining* Vegetable Oils *by* Emulsion; *in the treatment of* Sweet-Almonds.

1. *If instead of committing the almonds, or other proper subject, prepared after the manner of the nineteenth process, to the press, they were gently ground with clear warm water, in a marble mortar, their oily part would dissolve therein into a sweet, thick, turbid, milky liquor, in every respect, when strained off, like the chyle in an animal body; and which we call an* Emulsion. *The process.*

2. This emulsion may be prepared from all manner of nuts and seeds, but from no other parts of a plant. The operation takes out from the subject, the oil, and whatever else is soluble in warm water; whence the emulsion must contain some quantity of salt. And if the remains be now squeez'd in a press, they will afford no more oil, which by the motion, or attrition, required to fit the subject for this process, is so broke and attenuated, as readily *Its nature.*

dily to mix with water, and turn it to a milky, white, ſaponaceous, mealy liquor.

*Nature of the production.* 3. If this liquor be ſuffered to reſt for the ſpace of five or ſix hours, in a cool ſeaſon, or four in a warm one, it will, like the chyle of the human body, ſpontaneouſly ſeparate into two different parts; a cream, or butyraceous matter, which floats on the top; and a whey, or, aqueous part, which remains below, and ſoon turns of a blue colour and grows ſour. Whence we may learn, that emulſions, when preſcribed as medicines, ought never to be kept above ſix hours in the winter, and four in the ſummer, before they are made uſe of.

*Mechanical uſe of the proceſs.* 4. This operation, in a ſimple and wonderful manner, explains the action of the mouth, œſophagus, ſtomach and inteſtines, upon the aliment taken in. Two actions, with their effects, cannot be imagined more alike, in all their circumſtances, than theſe. The things we principally feed on are mealy ſeeds, or bread, fruits, *&c.* upon all which, the teeth and jaws act as the peſtle and mortar in our preſent proceſs; only nature makes uſe of the ſaliva, bile, and pancreatic juice for the menſtruum; whilſt our artiſt employs nothing but water. The ſtomach and inteſtines are the preſs, driven by the force of the periſtaltic motion; and the lacteal veſſels, the ſtrainer, to ſeparate the pure emulſion from its fæces, or chaffy matter which remains behind in the inteſtines. Whence we have the reaſon why the chyle is white, rather than of any other colour; namely, becauſe the ſalt, oil, and water of our food are mix'd and blended together, in ſuch a particular manner as always conſtitutes whiteneſs in liquors, or turns them into emulſions; tho' the food itſelf might originally be black, or of any other colour.

*The doctrine it affords, with regard to natural philoſophy and medicine.* 5. Hence we may underſtand, (1.) The origin and riſe of oil, both in vegetables and animals. The alimental juices of vegetables being ſuck'd in by their abſorbing veſſels, driven about by the force of circulation, and agitated by the heat of the ſun, at length depoſite their more unctuous, thick, and glutinous parts in their paſſage, or in proper cells, deſtin'd by nature to receive it. After the ſame manner in animals, this oily ſubſtance is taken in along with their food, and at length depoſited in the adipous cells; for we have before obſerved, that no vegetable ſubſtance is nutrimental, except it contains ſome proportion of oil: even graſs abounds therewith, eſpecially in its ſeed; ſo that being thoroughly mixed with the ſaliva, it turns milky; and, accordingly, there are ſome men would grow fat tho' they lived, perhaps, only upon bread and water. (2.) The nature and uſe of native vegetable oils. (3.) The manner wherein they may be changed into a milky liquor. (4.) The difference there is between them and other vegetable oils, gain'd by diſtillation; which will more fully appear hereafter. (5.) The origin and compoſition

position of chyle and milk in the human body; with the means to increase the latter in nurses. Milk appears to differ from chyle only as having been more concocted, and containing a larger proportion of salt, which renders some part of it convertible into curd, or a caseous substance, which neither chyle, nor an emulsion is capable of. Milk, therefore, is an oily, vegetable matter, circulated first in plants, then in animals, and capable of being reduced into a thick curdy substance, and a thin waterish one, which is called whey. This milk, if it finds no opportunity of passing off in its own natural form, turns to fat, or goes away with the urine and sweat, which is most commonly the case in men; for they generate milk as well as women, tho' they have not their vessels so well disposed to separate it from the blood. 'Tis also observable of milk, that the longer it circulates in the animal body, the more it loses of its own vegetable nature, and puts on that of the animal. Hence the rank taste in the cheese of *Liege*, which is made of the second milk, or that drawn from the cow an hour after she has afforded her first meal. Both the chyle and milk can only be composed of those parts of the food which are soluble in the saliva, bile, and other juices of the body, and capable of being expressed out by mastication, or the force of the stomach and intestines; such are, in particular, all mealy seeds, and oleaginous food that will readily dissolve in water, or the fluids made use of as drink. (6.) Lastly, we may hence understand why milk and chyle are so apt to turn acid; for this is the property of vegetable juices, which affect a kind of fermentation, and to which the chyle and milk of animals are very nearly allied.

## PROCESS XXI.

*Exhibiting the method of obtaining* Vegetable Oils *by* Coction; *from an* Example *in the* Remains *of the two preceding processes.*

1. *If, when by either of the two preceding processes the native oil seems to be entirely expressed, or drank up from the subject, the remains be for a long time boiled in water, over a strong fire, there will appear swimming on the surface, an unctuous matter, partly in the form of froth, and partly in that of a fat substance; which being lightly scumm'd off as it rises, and put to the rest, will at length amount to a considerable quantity of oil.* *The process.*

2. This was first observed by the excellent M. *Homberg*; and if any recent, and very unctuous vegetable substances were to be thus treated, such *How performable to advantage.*

such as almonds, cocoa-nuts, &c. they would afford two thirds of their original quantity in oil. And such bodies as will not afford their oil by expression, or by grinding them with water, may, by this method of coction, be made to yield it in plenty. Thus several fruits, plants, and seeds, and particularly beans, being gently dried and bruised, will, by boiling, give out a copious oil.

*The nature of the production.* 3. The oils obtained after this manner, have all the general properties of express'd oil, but retain nothing of the peculiar virtues of the subject; for these either fly off in the operation, or remain in the decoction. They contain a combustible matter, which is usually found in extracts, and cannot be rendered volatile by boiling; and whatever is not volatile, with regard to the degree of fire here employed, must stay behind, either in the subject or decoction.

*The process carried higher.* 4. If the decoction be, at length, exhaled away to the consistence of an extract, it will be found to contain a large quantity of salt; which being detained by the water of the decoction, could not rise to mix with the oil.

## PROCESS XXII.

### *Exhibiting the manner of obtaining the* Native, *or* Essential Oils *from the* Leaves *of* Vegetables, *by distillation; in the treatment of the leaves of* Rosemary.

*The process.* 1. *TAKE the leaves of rosemary, or any other plant, gathered in perfection, and gently dry them in the shade, till the more fluid part of their water is exhaled away; then cut or bruise them, and pour thereon ten times their own quantity of pure rain-water, acidulated, or made gratefully acid with a little oil of vitriol; and thus let them stand in digestion, with a very gentle heat, for three or four days; and afterwards distil off the water with a brisk fire, till it begins to run insipid or acid, as in the common case of distillation, before described; for the essential oil of the plant will come all away with the distill'd water; from which it may be separated after the manner which we shall shortly deliver*.*

*How performable to advantage.* 2. All manner of plants, with their several parts, as flowers, seeds, bark, wood, &c. are fit to undergo this process; but especially the aromatic and oily vegetables. Even grass, thus treated, would afford some quantity of oil, tho' slowly, and with difficulty. But those subjects, or parts of vegetables, are the most proper to be treated in this manner which are highly odoriferous, when their more watry

* See the thirty-first process.

part

part is by gentle exiccation driven away. For which reason, the flowers design'd for it, should be gathered whilst they are crisp, or before they open and expand themselves entirely; and the leaves, before they are fully unfolded. These subjects ought always to be dried gently in the shade, because the heat of the sun, in exhaling their superfluous water, would carry away a great part of their fine volatile oil too; leaving the rest united with the fixed oil, and unfit to be diluted or softened with warm water. Thus mint gathered in the month of *May* or *June*, and gently dried, will yield a greater plenty of oil than at any other season; tho' it may at all times be had fit for distillation. But the oil of this process comes over more light and subtile, tho' in much less quantity from the flowers, than it does from the leaves of plants.

3. The whole secret of the digestion consists in this, that after the subject has once been a little dried, it may again be soften'd, so as to relax the fibres of the vessels containing the oil, that it may easily be melted down, and come out readily, after those vessels are burst by the heat. Spirit of sea-salt, oil of vitriol, or any other acid spirit is added, to the rain-water to fetch out the unctuous parts of the subject, preserve the whole from putrefying by so long a digestion, and keep in the natural scent thereof; which would otherwise be lost, and a fetid, or disagreeable one be found in its stead. This method ought more particularly to be observed in distilling the oils of very costly plants, because it doubtless increases their quantity considerably: not that it adds to the oil; but as there are two kinds of it in plants, one which is found pure and unmixed with any thing else, and another which is united with the matter of the alkaline salt of the subject, the acid made use of by drawing to itself that alkaline salt, sets the oil free to ascend in greater quantity with the distill'd water. Thus were I to distil cinnamon for its oil, I would first digest the bark with acidulated water for some days, and then the operation, as Mr. *Homberg* has taught, will be much more gainful and advantageous. But the quantity of the acid to be added, and the time of digestion, are to be proportioned to the closeness and specific gravity of the subject. Thus, when we are to distil dry herbs, whose leaves are hard, or brittle, and not disposed to unfold themselves in water, or give out their oil, we may put them into a kind of brine, or rain-water made saline with sea-salt; and then digesting them for a proper time, as a week or two, in a close vessel, the subject will thereby be so mollified, as easily to part with its oil, by a brisk distillation. And this is the great secret practised in *France* and *Germany*, in distilling the oil of jasmin, *&c.*

4. Another secret with some persons, in order to increase the quantity of their essential oils in distillation, is, instead of common water, to pour the distill'd water of the subject back upon more of the same, or even to use the cohobated water for that purpose; for as the water

ter impregnates, or ſaturates itſelf with the oil of the plant in the firſt or ſecond diſtillation, it can afterwards abſorb no more; and therefore leaves the reſt free to aſcend along with the other water that runs off. But as to what ſome authors write of increaſing the quantity of diſtill'd oils, by the uſe of certain mixtures, as if they by that means cauſed the plant to afford more of it than what it naturally contained, 'tis trifling to pretend to any ſuch thing; ſince 'tis not in our power to create oils, but only to ſeparate them from the ſubjects wherein nature has lodged them.

*How to be conducted.* 5. 'Tis particularly requiſite here, that we begin the operation with a briſk fire, which is another means of increaſing our quantity of oil; for thus we ſhall prevent what is already ſeparated and diſſolved, from falling back, entangling with, or ſinking into the ſubject again; which it would do, if a ſlow fire were uſed. But we muſt immediately ſtop all farther proceedings, as ſoon as ever the acid liquor begins to run; otherwiſe we ſhould foul our oil, and cauſe it to grow rancid. When the flowers or leaves of *European* plants are made the ſubject of this proceſs, the oil, that comes over, ſwims on the ſurface of the water; but that obtained from the aromatic vegetables of *Aſia* and *America* always ſinks to the bottom: and in both caſes it appears of a different colour, and is obtained in different quantities, according to the nature of the plant.

*Its rationale.* 6. This operation, then, appears to be perform'd in an eaſy and mechanical manner. For the oily veſſicules of the plant being firſt ſoak'd and ſoften'd, are broke by the action of the fire; or their contents ſo diſſolved by the heat, that they mix with the boiling water; whence, by the continued action of the fire, they riſe in the form of vapor, along with the water, and are ſtopp'd and condenſed by the ſtill-head, and forced to run out cool through the worm of the refrigeratory; and ſo a liquor comes away that is richly impregnated with the ſcent and taſte of the ſubject. The degree of heat here made uſe of, being no more than that of boiling water, is unable to force up any of the ſolid parts of the plant, but only raiſes ſuch as are liquid and volatile; whence the oils are ſuppoſed to come away pure, not greatly differing from what they naturally were in the plant: hence, among the chemiſts, they are not improperly called eſſential oils; ſince they perfectly retain the taſte, ſmell, and ſpecific virtues of the ſubject. And as we often call that the eſſence of a thing, which by its properties makes it known from all others in nature; as mint is diſtinguiſhed from wormwood, by its peculiar taſte and ſcent, which reſide in its oil; hence ſome chemiſts call theſe oils the quinteſſences, or concreted ſulphurs of vegetables. They can be obtained by no other means beſides diſtillation; nor then neither, without the addition of water, (which, by aſcending with them, keeps them from growing rancid, and prevents the empyreuma) and the

the uſe of a refrigeratory to condenſe them. Which method of diſtillation being unknown to the antients, they were never acquainted with the great virtues of theſe eſſential oils, as we may learn from *Galen.*

7. If theſe oils are rectified, or briſkly diſtilled over again with freſh water, by the alembic, they become much purer and finer; continually leaving ſome proportion of earth behind them, and loſing a part of their ſpirit. The water, which thus comes over along with the oil, retains the perfect taſte and ſmell thereof; and at length, after repeated rectifications, becomes ſo ſaline as to precipitate a ſolution of mercury-ſublimate. But when this operation is often repeated, the oils loſe conſiderably of their quantity, and grow almoſt inſipid. By diſtilling ten ounces of the eſſential oil of aniſeeds ſix and twenty times over, with freſh water, I reduced it to two and a half. And thus if the oil of cinnamon were frequently to be diſtilled in the ſame manner, the water that runs off would appear milky, and the oil diminiſh in its quantity; ſo that at length, by this means, it would entirely free itſelf of its ſpirit, ſalt, and earth, and be reduced to a very little portion of a fattiſh ſubſtance, reſembling wax. After the ſame manner theſe oils, being barely ſhook in water, would reſolve themſelves into four parts, *viz.* the native ſpirit of the plant, a ſalt, which diſſolves in the water, a ſaponaceous ſubſtance, or a mixture of oil, and ſalt, and an earth.

*Effects of continuing it farther.*

8. Theſe oils being diſtill'd frequently over, *per ſe*, in a clean glaſs retort, ſeem wholly convertible into mere fixed and inſipid earth; for let the operation be repeated ever ſo often, there will conremain at the bottom of the retort ſome quantity of ſuch an earth. This was firſt diſcovered by the excellent Mr. *Boyle*, who made the experiment with oil of turpentine and oil of aniſeeds; and conſtantly found it to ſucceed, tho' the diſtillations were repeated a very great number of times; ſo that from a pound of his ſubject, ſcarce an ounce remain'd unconverted into a pitchy matter, or black earth. This we find deliver'd in that admirable piece of his, where he undertakes to ſhew, that chemical principles are tranſmutable into one another. And the like experiments with theſe have been made at *Paris*, even upon the moſt rich, precious, and coſtly aromatic oils of *Aſia*. The ſame thing is alſo obſerved by *Helmont*, in his *Aurora Medicinæ*, of the oil of human blood; which being diſtill'd a number of times over ſucceſſively, always leaves a quantity of earth behind it, that cannot be rendered volatile.

*Nature of the production.*

9. If our eſſential oils be diſtilled off from quick-lime, calcin'd chalk, or the like, for ſix times running; a pound of them will afford fifteen ounces, or more, of phlegm, or water, and leave not above an ounce of pure oil behind in the retort, as M. *Homberg* has experienced. But the addition in this caſe being renewed every time, 'tis

poſſible that ſome ſmall quantity of the phlegm may be afforded by that.

10. When theſe oils are firſt lightly digeſted with alcohol, or a pure and high rectified ſpirit of wine, and then diſtill'd again with a very gentle heat, as that of the *Balneum Mariæ*; the native ſpirit, or ſoul of the plant lodged in it before, which gave the taſte and ſcent to the oil, now riſes with the alcohol, and leaves nothing but a reſinous, inſipid, and ſcentleſs body behind. Thus by diſtilling oil of cinnamon, for inſtance, with pure ſpirit of wine, we may bring over all that was ſpecific in the oil, or bark, and gave the peculiar ſmell and taſte whereby each of them was diſtinguiſhed from other bodies; leaving all the oil untouched at the bottom, in the form of a roſin. And thus we have a method of ſeparating the pure ſoul of plants from their bodies. We ought not therefore to deride the ancient chemiſts, when they tell us we are to ſeparate the ſoul from a ſubject by menſtruums adapted to the work; for in the preſent caſe we ſee that perfect alcohol, which is nothing but a pure, ſubtile oil, draws to itſelf the fine ſpecific and aromatic part of the cinnamon, which conſtituted it the body it was. Which ſpecific part, if we could obtain it alone, without any mixture, might properly be called the eſſence of the plant. Some of the moſt judicious chemiſts have called this ſpirit the offspring of the ſun, on account of the phyſical cauſe of its production. And tho' it has been their fortune to be laugh'd at by ſome men for this; yet herein they ſpoke with as great accuracy as truth. They juſtly obſerved that there are a ſpirit, and two kinds of oil in plants; the one a glutinous body, which they term'd fixing ſulphur, and the other a volatile oil, wherein the ſpirit of the plant reſides, and which is endued with a cauſtic virtue; for if applied to the tongue, or other part of the body, it burns like fire, but when waſh'd in water, loſes its acrimony, and becomes innocent. For thus 'tis ſeparated from its ſpirit, by means whereof it produced ſuch effects, and is turned to an inſipid, inodorous oil; whence this ſpirit may not improperly be called a creature of the ſun, or of fire. But farther, the moſt fiery oils are thoſe which come from the hotteſt countries; and, indeed, appear to be nothing but a parcel of fire wrapp'd up in a proper unctuous matter, fit to detain it; as hath been render'd probable from ſome experiments, not long ſince made in *England*. For ſome gentlemen of the royal ſociety found, that if a little oil of cloves, or cinnamon, were in ever ſo cold a place, mix'd with the cold ſpirit of nitre, they would immediately break out into a flame, which was their aromatic part. And *Helmont*, in his treatiſe *De Tribus Principiis*, inſtructs us how to know when plants abound with, and when they are deſtitute of this oil.

11. After

11. After the same manner, any aromatic essential oil, being long exposed in an open vessel to the free air, will lose its native spirit, and become insipid and scentless, without any considerable loss of weight. Thus a dram of the essential oil of cinnamon, put to cover the bottom of some wide, shallow vessel, wou'd, in a few days time, be deprived of its specific taste and scent, by the air which we suppose to have free access thereto; tho' during that time its diminished weight would scarce be sensible upon the balance. Hence we might be furnished with a method of determining the quantity of this native spirit in the essential oils of vegetables, which, according to *Sandivogius*, is incredibly small, or not more than one part in three thousand and six hundred of the plant. And that this proportion is not rated too high, will appear by the following experiment; which I made on purpose to determine it. From a pound of choice biting cinnamon, I drew all the oil by distillation, after the manner of our present process; and found all that was sunk to the bottom of the water amounted to no more than ten very small drops; as 'tis the nature of this oil not to fall in large ones. Then in order to find how much oil was contained in the milky water that run off along with the former drops; I let some of them fall into a quantity of fresh water, till, upon shaking, it appeared just as milky as the other; and making my calculation accordingly, I found about thirty drops of oil were mixed with the distilled water; so that the whole quantity of oil obtained from my pound of cinnamon was forty drops. In the next place, that I might discover what part of this quantity was owing to the native spirit of the cinnamon, I let fall some drops of the oil upon a glass plate, and exposed them to the air; and found, in a few months time, that they had entirely lost both their smell and taste, so that the remaining part of the drops could not be known from tallow, or any other rancid oil; yet during all this time it had lost only the fortieth part of its original weight: whence we may pretty fairly conclude, that all the native spirit which gave the aromatic virtue to the whole pound of cinnamon, amounted not to above the quantity of a single grain. * It seems to be the office of the remaining part of the oil to preserve and detain this fine, volatile spirit, or reigning principle of the plant; which must needs be of a prodigious force and virtue, since a single drop of the essential oil of cinnamon (only one fortieth part whereof can be this spirit, as we just now saw,) will communicate a rich, aromatic flavour to five pints of wine; or if the same quantity be first mixed with sugar, and so dissolved only in common water, it will make a cordial, which, being drank, surprisingly recruits the

* It appears very difficult to make this experiment with any tolerable accuracy; because at the same time that either fire, air, or spirit of wine, acts upon the oil, so as to deprive it of its native spirit, no inconsiderable quantity of the other volatile parts of the oil will also be exhaled, absorbed, or lost. And if due allowance be made for this consumption, we may reduce the animating soul of plants to a very slender bulk indeed; so as to make it seem little more than an *aura*, a *halitus*, or delicate vapor; which is entangled, and fetter'd down by the oil.

animal ſpirits, and inſtantly reſtores the body from a ſtate of languor and depreſſion.

12. When ſome of theſe eſſential oils are kept for any long time in well-cloſed veſſels, they appear to be converted into a kind of ſalt. This is principally obſerved of the rich *Aſiatic* oils; and I my ſelf have lately ſeen an inſtance of it, in a parcel of genuine oil of cinnamon, preſented me by a friend, returned from the *Eaſt-Indies*; and which had been kept for the ſpace of fourſcore years. It was a perfect ſalt that would diſſolve in water, and not a concreted ſaponaceous ſubſtance, as I had formerly been apt to ſuſpect, and have ſeen inſtances of. But this is a curioſity which few have been ſo lucky as to ſee; for 'tis true, as M. *Homberg* ſays, that the ſalt requires a great length of time to form in; and the experiment is not eaſy to be made ſhorter. Not to mention that experiments of this kind would require the purſe of a prince. *Celſus*, however, obtained a ſight of the ſalt of cinnamon, in the iſland *Ceylon*, upon opening a veſſel full of the oil wherein it was ſhot: and poſſibly the ancients had a way of converting this ſalt of cinnamon, into a ſtone; which *Helmont* aſſures us may be done, by a long continued circulation. But this phenomenon is hardly to be expected in the crude, unripened oils of *Europe*.

*Phyſical concluſions from the proceſs.*

13. Hence we may obſerve. (1.) That the taſte and ſcent of plants do not at all depend upon their oils, properly ſo called, but entirely upon the native ſpirit reſiding in them: which being ſo exceeding ſmall in quantity, gave occaſion to *Ludovicus* to call it *Scintilla ſpirituoſa*, the ſpark of life. Whence he was of opinion that if we cou'd get it out of a vegetable, pure, and by it ſelf, we ſhould then have the real quinteſſence thereof; and ſo by giving a ſingle drop to two of the quinteſſence of any ſubject, do as much in the cure of diſtempers, as we could by giving very large quantities of them in ſubſtance. (2.) That the taſtes and ſcents of the waters diſtilled from vegetables depend upon the ſame cauſe; part of the native ſpirit being mixed with the oil, and detained in them by it. (3.) That there are two kinds of oils in plants; *viz.* a light one, which is the proper vehicle of the native ſpirit, and a fixed one, which appears to be the ſame in all ſubjects, and ſerves as a glew to the terreſtrial part. (4.) That the oils obtained from vegetables by diſtillation are ſuch as pre-exiſted in the ſubjects. And (5.) That theſe eſſential oils may be changed both into earth and water.

*Medicinal virtues and uſes of the production.*

14. All theſe diſtill'd eſſential oils are acrid, hot, inflammatory, refreſhing, cardiac, attenuating, and ſtimulating; upon which accounts they are of admirable uſe in diſtempers proceeding from a cold cauſe, or in the diſorders incident to old-age, eſpecially when the body abounds with phlegm; and alſo in caſe of intermitting fevers, proceeding from a lentor, and not having their cold fits diſtinct and regular; in hyſteric, hypochondriac, colical, and flatulent caſes, from a cold cauſe; or whenever the nervous fibres, or animal ſpirits ſeem torpid, and want to

be

be excited. But being highly inflammatory, their use is, by all means, to be avoided in all distempers proceeding from a hot or acrid cause, or even where there is only a suspicion of an inflammation; or the juices of the body are already too much thin'd and dissolved in their texture. Every thing is called acrid, which causes pain when applied to the bare nerves of the body; upon which account it is that we say these essential oils are acrid. They are also hot and inflammatory, because when applied in any considerable quantity to the skin, they excite a great degree of heat, and an actual inflammation attended with pain. Thus a drop of the essential oil of cloves, let lie upon any part, would eat into the flesh, and cause an eschar. And a very moderate quantity of any of them, if drank, wou'd presently inflame the stomach and intestines. These oils are so refreshing, that by being barely smelt to, or tasted, they immediately restore a person from the most languid or depressed state; and prove, when mixed with sugar, and dissolved in water, a noble and instantaneous cordial, reviving or recruiting the animal spirits. They have, moreover, a great attenuating and resolving power, by means whereof they insinuate themselves into any viscid matter, and break or dissolve it away; at the same time that they stimulate and excite the fibres of the nerves and muscles, to discharge and throw it off, when lodged or impacted in them; whence also they raise the spirits, and give a brisk motion to the nervous fluids. For this reason they cannot but be highly proper in all distempers from a cold cause, where the circulation is languid, and the juices viscid. But besides these general properties, of which all the essential oils of vegetables partake, they have all something peculiar to themselves, as containing the specific virtues of the plants; so far as these are discoverable by our senses. Thus the essential oil of mint, for instance, acts in the body by the general properties of all essential oils, and also by those which are peculiar to it self, and distinguish it from the oils of other vegetables. And upon those two principles of action depend all the virtues of plants. Thus the oil of savin is peculiarly adapted to provoke the menstrual flux, when obstructed by any viscid cause, and a want of force in the circulation. The like is also proper in any viscid or cold disorders of the *uterus*, being taken in the quantity of three or four drops in sugar, or any proper vehicle; which is a medicine that will also forward and promote the exclusion of the *fœtus*, when the delivery is retarded by any cold cause, or weakness on the side of the mother: but it ought only to be given where there is a want of strength; otherwise it might do mischief, by stimulating too much. The essential oil of rue is good against the epilepsy, when it proceeds from a relaxation of the nerves; that of mint, for a weak and cold stomach, and to stop a vomiting; that of juniper against the cold scurvy, and the nephritic pains proceeding from it; that of lavender, in case of convulsions, the falling-sickness, the palsy, vertigo, weak nerves, and all cold disorders of the



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head; that of fennel for cold flatulencies in the ſtomach and inteſtines, or when they are weak and unable to perform their office: the oils of tanſey, wormwood, and the leſſer centory are powerful remedies, and almoſt ſpecific for worms in the body; oil of roſes excellently refreſhes the languid ſpirits; oil of citron-peel prevails againſt the palpitation of the heart; oil of baulm againſt melancholy, proceeding from a cold cauſe; and the eſſential oil of cinnamon is a noble hyſteric; and in fainting-fits, from want of motion in the ſpirits, a moſt powerful cordial.

## PROCESS XXIII.

*Exhibiting the manner of diſtilling* Eſſential Oils, per veſicam, *from the* Flowers *of vegetables; by an example in* Camomile-Flowers.

*The proceſs.* 1. *LET fine camomile-flowers, fully ripe, gathered early in the morning, and gently dried in the ſhade, ſtand in digeſtion, with a ſufficient quantity of pure rain-water to cover them, for the ſpace of four and twenty hours; and afterwards proceed to diſtillation, in the manner of the preceding proceſs. That which runs off firſt will be a water, retaining the perfect rank ſmell and taſte of the flowers: then follows a water impregnated with a fine azure oil; and at length, if the diſtillation be continued, a clear or acid liquor; which is by no means to be mixed with the former.* (2.) *Now ſtrongly preſs out the decoction from the flowers, and pour it back, together with all the odorous water and oil that was before diſtilled off, upon freſh flowers; adding alſo, if there be occaſion, a little more rain-water. Suffer all to digeſt for twenty-four hours more; and then diſtil off the water and oil, as before. And by this means, if the operation be frequently repeated, you may at length obtain a very large quantity of oil, in a high degree poſſeſſed of the taſte, ſcent and virtues of the flowers.*

*How performable to advantage.* 2. The native ſpirit of plants generally ſeems to reſide in no part ſo much as in their flowers; for which reaſon they ought to be gathered and dry'd with great caution for this operation. But there are ſome of them, which tho' they prove exceedingly odoriferous, yet afford but a very ſmall quantity of eſſential oil, by diſtillation, unleſs they are for a long time firſt digeſted with water, made ſharp by ſpirit of vitriol, ſpirit of ſalt, or the like. And, indeed, we conſtantly obſerve, that the more odoriferous any flower is, or the more native ſpirit it contains, the leſs eſſential oil it affords; as is evident in jaſmin-flowers, lilies, &c. Thus the oil of damask roſes, on account of its ſcarcity, and the great labour and expenſe required to obtain it, was formerly ſold as dear as gold; and even eſteemed by ſome people as a non-entity. But M. *Homberg* has ſhewn us, that if ſuch roſes be digeſted for a month in acidulated water, they will afford a very conſiderable proportion of oil; tho' otherwiſe a large parcel of them would yield ſcarce any at all by diſtillation. 'Tis very obſervable, that the eſſential oils of plants differ in their

their colour, with the nature of the subject; thus the oil of our present process is of a fine blue or azure; that of wormwood, green; that of mint, yellow, or gold-coloured; that of lemmon-peel pale, &c.

3. The medicinal virtues of our oil of camomile are carminative, and anti-colical, which render it serviceable in flatulent cases; and if it be mixed with the extract prepared from the remaining decoction, after the distillation is over, it affords a medicine for agues or intermitting fevers, scarce inferior to the *Peruvian* bark; being endowed with an admirable diaphoretic and resolving quality. A dram of the extract, mix'd up with two or three drops of the oil, may be given two or three hours before the fit is expected, in order to prevent it: or, otherwise, we may exhibit it after the same manner as the bark. *Virtues and uses of the production.*

## PROCESS XXIV.

### *Exhibiting the manner of distilling* Essential Oils *from* Seeds *and* Berries, per vesicam; *by an Example in* Fennel-Seed.

1. TAKE *fennel-seed, gathered on a clear day, when fully ripe, and carefully dry'd in the shade, and set it to digest for fourteen days in so much rain-water, acidulated with oil of vitriol, or made saline with common salt, that it may commodiously swim about therein; and afterwards distil off the water, exactly in the manner directed above; and the oil will come away along with it: but observe to let the fire be gentle at the first.* *The process.*

2. All manner of aromatic seeds and berries are proper subjects for this process; such as cummin-seed, aniseed, juniper-berries, &c. which will afford a very large proportion of oil: whence it appears that these parts of vegetables are very oleaginous and unctuous. And this gives us to see the reason, why the seeds of vegetables are capable of remaining perfect in their taste and scent, and fit for vegetation, during so long a season as we find they do, when guarded from too great a quantity of moisture and heat. For the large quantity of oil they contain, defends the *embryo* from all the violence and injuries it would otherwise receive from the air or water, with whatever is contained therein. Every seed contains a little seminal plant, or *embryo* in the middle, between its two lobes, which serve as a *placenta uterina*, and contain little vesicles of oil to defend and preserve it; but when once any moisture comes to penetrate these lobes, the seminal plant begins to shoot and grow; but whilst these lobes remain dry, or unaffected by the moisture, whether of the air or earth, they defend the *embryo*, as trees are kept from the winter's cold, by the oil which is then plentifully lodged in their bark. But when any seed comes to be steeped in water, the moisture gets into it, *What subjects are fit for it.*

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rarifies the oil, and cauſes the ſeed to ſwell, open, cleave into two parts, and then the oil is gradually conſumed, or drained out of its cells. And if at this, or any other time, the ſeed ſhould be deprived of its native or preſiding ſpirit, 'twould no longer be fit for vegetation. Thus if any ſeed be once put to ſoak in water, and afterwards dry'd, then ſoak'd again, and committed to the ground, it will never ſhoot, but dye and moulder away; becauſe, by this means the native ſpirit, which ſhou'd give motion to all its parts, having been ſet looſe from the oil, is now flown off. But by keeping vegetable ſeeds in a dry place, this effect will be prevented: and thus ſome kinds of grain may be preſerved in a ſtate of perfection for ten, twenty, or thirty years, and ſtill be fit to grow again, when ſown. And hence alſo we may ſee a reaſon why fruits ſhould be endowed with a certain proportion of oil, as we find they are.

*With what caution to be performed.*

3. In diſtilling off the oils from ſome ſeeds, as particularly thoſe of aniſe, caraway, daucus, *&c.* after the manner of our preſent proceſs, we find the oil apt to ſtick in the worm, and clog it up with a thick concreted matter; to prevent which 'tis neceſſary to leave the worm for ſome depth uncovered with the water of the refrigeratory, that the heat thereof may melt the oil, and carry it down into the receiving veſſel below. Or if that be not ſufficient, we muſt diſſolve the coagulated matter, by running hot water thro' the worm. This concreted matter, or oil, is, in reality, no other than the camphire of the ſeeds; for camphire is not peculiar to any one tree or vegetable; but all aromatic plants produce their camphire, which is only the native oil, by length of time concreted and hardened into a white, fat, tranſparent maſs, called by that name. Thus the oil of ſeveral plants in the iſland *Ceylon*, and particularly that which diſtils from the cardamom-ſeed, is almoſt wholly converted into camphire. And this may ſerve to ſhew us, that our eſſential oils muſt needs be very rich in their nature, as greatly participating of the aromatic parts of vegetables; and being, in reality, but a fluid kind of camphire.

## PROCESS XXV.

### *Exhibiting the manner of obtaining* Native Oils *from the rich and hot ſpices of* India; *by the treatment of* Indian Cloves.

*The proceſs.*

1. D*igeſt entire* Indian *cloves, that have never been robb'd of their native oil, in twenty times their own quantity of rain-water, for the ſpace of four and twenty hours; then commit them to the alembic, and proceed as in the preceding proceſſes, and there will run off a thick, milky, odoriferous, and aromatic water, of a fiery taſte, and containing a very large proportion of oil, which*

*will*

*will sink to the bottom of the water, and prove so intolerably hot and fiery, as not safely to be touched with the tongue.* (2.) *When the hot aromatic water seems to be all run off, pour fresh upon the remainder, and repeat the distillation, to draw all the oil out of the subject; and at last there will run off a clear, acid liquor, very different from the former, which is to be kept separate by it self.*

2. The vegetables which grow in the hottest countries are always of the most aromatic and fiery nature, and afford the heaviest and hottest oils by distillation. Thus the essential oils of cinnamon, *Winter*'s-bark, galangal, pepper, cardamoms, ginger, *&c.* seem to be concentrated fire; for when applied to the skin of the human body, they burn like a caustic. But among all the aromatic productions of the *Indies*, none seems to abound more in oil than cloves; for which reason they require the greater quantity of water in their distillation. But they seldom come to us, till they have been deprived of their oil; the best part whereof is commonly drawn from them in the *Indies*; after which they are, perhaps, mixed up with some that are better, which communicate to them their smell and taste, and make them appear as we commonly find them: but naturally they are so very unctuous, that their oil may be express'd, and made to drop from them by the fingers. Nor does any oil appear to be of a more fiery nature than this of cloves; for if mix'd with twice its own quantity of spirit of nitre, it will turn to flame in an instant. And by being barely kept for a few days in the open air, it loses all its hot, aromatic virtue; and the remainder becomes rough and unactive. The high price at which both this and other aromatic oils of the *Indies* are sold, frequently occasions them to be adulterated with oil of almonds, or the like; but the cheat may easily be discovered, by the want of their due specific gravity, or their slow descent in water.

*How performable to advantage.*

3. The cloves which remain after this process is perfom'd, appear to have lost all their taste and scent, but when soak'd in fresh water, swell and recover their natural bulk; which gives occasion to their being sometimes sold so cheap at *Amsterdam*: for 'tis very easy to throw a parcel of fresh cloves among those which have thus been robb'd of their oil, and put them off for genuine.

4. This oil made into an *elæosaccharum*, and mixed with wine or water, affords an admirable remedy for women in labour; or in case of langour and faintness during the time of their lying-in: 'tis also of very great service to alleviate, or put by the fit of an intermitting fever.

*Medicinal uses of the production.*

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## PROCESS XXVI.

### *Exhibiting the manner of distilling* Essential OILS *from the* Barks *of* Vegetables; *by an example in* CINNAMON.

*The process.* 1. *TO a proper quantity of strong, fresh, fragrant, weighty and biting cinnamon, broke into small pieces, pour ten or twelve times its own quantity of the distilled water of cinnamon, acidulated with spirit of vitriol, and proceed immediately to distillation, as in the former cases; and there will run off a very thick and white odoriferous water, which, being received in a pure vessel, will deposite an oil of a golden colour, and of an exceeding pungent and fiery taste.* (2.) *Pour fresh boiling water frequently upon the remains, to prevent any empyreuma, and to bring off the whole quantity of the oil: and continue doing thus, till the clear, insipid or acid liquor begins to come; which is so apt to corrode the still-head, and thereby gain an emetic quality. The oil will be found only in a small quantity; the distilled water being very richly impregnated with the rest* *.

*How performable to advantage.* 2. If you would increase the quantity of your oil, add a large proportion of salt, or oil of vitriol to the water first poured upon the subject; for such an addition has the power to volatilize vegetable oils: † and let all the water made use of be what has already been distilled from cinnamon, and retains the perfect scent and taste thereof. Those barks which even in the cold prove odoriferous and volatile, need no previous digestion; but may directly be submitted to the operation; as the bark of sassafras, for instance, and our present subject cinnamon: for a long digestion would rather consume than preserve their volatile oil. But all the barks to be distilled for their oil, should be taken from the boughs, or near the roots of old trees, during the autumn, or the beginning of winter; for then the bark abounds most with gum, rosin, or balsam: but in hot countries the wood often contains as much oil as the bark. When the bark of any tree proves hard, being first carefully dry'd, it may be shaved, or reduced to a gross kind of powder, and digested in salt-water, to make it afford its oil to greater advantage; by which means it may be brought to yield a larger quantity than the wood of the same tree, and appears possessed of greater virtues.

4. The remains of our subject, after distillation, no longer retain the least smell or taste peculiar to cinnamon, but are now as austere and scentless, as if they were the bark of an oak: they retain, indeed, their own na-

* *Glauber* has a way of obtaining the rich and costly vegetable oils, to profit, with spirit of salt alone; which he pours upon the subject and distils in a sand heat; all the oil thus commodiously rising along with the aqueous or phlegmy part of the spirit; from which it may readily be separated, without loss.

† It also seems to mix with them, and somewhat alter their natural flavour.

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tural form, but nothing more. Yet even this property, when cunningly made ufe of, will turn to advantage; for cinnamon, thus treated, may be dried and mixed among fome that was never fubmitted to diftillation, or but in a fmall degree; and fo be fold undifcovered in large parcels.

*Medicinal virtues and ufes of the production.* The effential oil of cinnamon is exceeding ftrong and fiery; a fingle drop of it being enough to burn the tongue, and caufe a gangrene. A fervant-maid being once fet to look after fome of this oil, as it ftood over the fire, unluckily clapp'd a little of it to her mouth, with the end of her finger, as it happened to run down the fide of the veffel; which immediately burnt her lips, jaws, and all the parts of her mouth, like fire; whence a gangrene prefently followed, and in two days after, notwithftanding all the means that could be ufed to prevent it, death. But when this oil is properly ufed, or mix'd with fugar, and fo diluted in wine or water, 'tis a moft admirable cordial; at once both warming the body, and raifing the fpirits. Not only the oil, but alfo the firft running of the water affords an incomparable remedy in all the cafes peculiar to women; and efpecially where the perfon is of a cold conftitution.

## PROCESS XXVII.

### *Exhibiting the manner of diftilling* Effential OILS *from* WOODS; *by an example in* SASSAFRAS.

*The procefs.* 1. R*Educe faffafras-wood to chips, or fhavings, pour thereon a fufficient quantity of rain-water; and immediately proceed to diftillation, as in the cafe of barks or feeds.*

*How performable to advantage.* 2. Thofe woods, which are very aromatic, and eafily yield their oil, efpecially if they be light and fpongy, fuch as our prefent fubject, need only be fhaved thin, and put to the water, in order to prepare them for diftillation. But thofe which are folid, clofe, dry, and heavy, fuch as *lignum aloes*, *lignum vitæ*, rhodium, *lignum ferri*, *Indian* cedar, (from whence drops myrrh, and the balfam *capivi*) the cedar of *Lebanon*, box, fnake-wood, &c. ought to be very long digefted in falt-water, or water impregnated with a confiderable proportion of fome acid fpirit, and that in veffels well clofed, to loofen the oil, and make it ready to afcend by diftillation. The fpace of feveral weeks is fometimes requifite to prepare the fubjects for this operation. Thus, if that heavy wood rhodium, which affords fo fweet an oil, or balfam, were to be boiled ever fo long, and a water diftilled from it, a very inconfiderable quantity of oil would be thereby gained; till once its body was unlock'd and open'd by a previous, and long-continued digeftion. But when ground to a courfe kind of powder, and put to fteep for the fpace

of two months, with a proper quantity of acidulated water, in very close vessels, it will copiously give out its incomparable oil in distillation. Any of these solid and ponderous subjects being thus prepared, and distilled in the same manner as was formerly said of seeds, will freely afford their oil, tho' in a less proportion than those; but generally in the greater plenty, as they are more odorous, and of greater specific gravity, with respect to one another.

*What subjects are best fitted for it.* 3. All those woods which contain any quantity of turpentine, rosin, gum, or unctuous matter, are proper subjects for this process; but those which shoot apace, or grow in damp or watery places, as the willow, the lime-tree, the poplar, *&c.* are very unfit for it; being soft and spungy, and affording but a very small quantity of oil. The trees which grow between the tropics are generally fit to distil for oil, which proves so heavy as to sink in water, and render the liquor they afford in distillation exceeding white and milky. And, in general, the heavier and more dense the woods are, the more oil they afford by the treatment of our present process; and the more porous, brittle and crumbly they become, after they have once undergone it. The wood of those trees which is cut when they are grown old, as also that fell'd whilst they were very young, or in the spring-season, gives but a small proportion of a less perfect oil, by distillation; in comparison of what that does which was cut in the first of the winter, from a middle-aged tree, and afterwards gently dried.

*The physical doctrine it affords.* 4. And this may give us to understand whence the weight, durability, hardness, native balsams, and rottenness of wood proceed. The gravity of any wood is, without dispute, proportionable to the quantity of oil it contains. Thus *lignum vitæ*, that naturally sinks in water, will float thereon after its oil is extracted by distillation; whilst the oil itself will presently fall to the bottom. And 'tis a general rule, that the least oily woods are always the lightest; and *vice versa.* The oil of vegetables, therefore, appears to be their heaviest part. All the woods that are durable, contain a large proportion of oil; but those which cannot long remain uncorrupted, a small one. Thus any utensils made of the lime-tree, for instance, which greatly abounds with water, and but little with oil, will scarce last longer than a year; whilst those of guaiacum, cedar, *&c.* which are copiously stock'd with oil, hardly sustain any damage by time. Whence the antients chose to build their ships of cedar. The more any wood is filled and swelled with oil, the harder it constantly proves; of which we may have a plain instance in the *lignum vitæ*, by comparing two pieces of different ages together; for the oil turning to a kind of gum, or strong flinty matter in the older, keeps all its parts firmly connected together, and renders the whole body of it compact and solid. Whence its essential oil is obtain'd with difficulty; and proves too hot and fiery to be used in medicine, without a deal of caution. The native balsam of woods,

woods, or that which ſweats ſpontaneouſly from the growing tree, and afterwards aſſumes the form of a roſin, gum or pitch, is nothing but the oil of the vegetable, made to flow out of its ſubject by the heat of the ſun, which then condenſes, and fixes it into a more ſolid form. Wood is ſubject to two different kinds of rottenneſs; that from the worm, and that from a loſs of its oil by exhalation. The worm, whoſe body and proboſcis are both exceeding ſoft and tender, has a ſurpriſing power of piercing the hardeſt wood; where, feeding upon the oil lodged in the cells, it gradually reduces the remaining part to powder. Length of time gives an opportunity to the ſun, the air, and other cauſes to act upon the ſubſtance of wood, and by degrees exhale its oil and volatile parts, ſo as at laſt to leave only a ſoft, crumbly ſubſtance behind, as we ſee in that rotten wood which has a luminous property; or elſe into a kind of aſhes, as if the ſubject had been calcined by the fire. And both theſe ſpecies of rottenneſs are obſerved to affect ſuch woods the ſooneſt, as leaſt abound with oil; ſuch are elder, willow, *&c.*

*Its phyſical and medicinal uſes.*

5. Hence we ſee, that the wood deſigned for fewel, and all mechanical and medicinal uſes, the building of ſhips, *&c.* ought to be cut in the winter-ſeaſon. All timber-merchants are acquainted with this; and accordingly, when they require wood in its perfection, and fit for ſervice, they have it brought from the coldeſt regions, where the trees contain a greater quantity of oil, than in ſuch as are hotter, or high montaneous places, which are always cold. The larger proportion of ſalt or water any wood contains, the more unfit it is for the uſes of the ſhip-wright, or architect; and therefore they never chuſe to cut it in the ſummer, or the ſpring, when trees are chiefly ſaline and aqueous; but either in autumn, when yet there is ſome quantity of water adhering to the oil, or in the beginning of the winter, when the pure oil is condenſed by the cold, and compacted with the wood, to defend the body of the trees from the froſt.

*Introduction to the next proceſs.*

6. Having ſeen how oils are obtainable from vegetables by expreſſion, emulſion, coction, and diſtillation with water, we are next to ſhew the method of obtaining them pure, as they exiſt in their ſeveral ſubjects, without any mixture of water, and by no greater degree of heat than that which makes them ſweat or diſtil from the tree.

## PROCESS XXVIII.

*Exhibiting the manner of distilling the pure native* OILS *of* Vegetables, per descensum; *by an example in* INDIAN CLOVES.

*The process.* 1. *LET fine, fresh, ripe, and unctuous cloves be lightly bruised, put into a clean linen cloth, and suspended, for some time, in the vapor of hot water, to soften and open them, so that they may the more readily give out their oil; then accommodate and fasten the extremities of the containing cloth, to the edge or rim of a deep glass vessel, and fit it with a concave cover of iron, and lute the juncture. Then in the hollow part of the metalline cover, strew fine sifted ashes, and place upon them a few live coals, that may gradually heat the spice all round, and cause its liquid parts to drop through the strainer, to the bottom of the containing vessel. An aqueous vapour will first descend, and appear in the form of water, retaining the perfect smell and taste of the cloves; and afterwards a small quantity of fine and excellent essential oil, which may be increased by augmenting the fire; but then there will be danger of giving an empyreumatical, or burnt smell and taste thereto.*

*How performable to advantage.* 2. All the aromatic and oily parts of vegetables are proper subjects for this process; such as cinnamon, mace, nutmegs, ginger, pepper, the roots of zedoary, galangal, angelica, master-wort, orange-peel, citron-peel, *&c.* which being gather'd when fully ripe, gently dried, bruised, and treated as above described, will afford a set of essential oils, which may at any time be expeditiously prepared, with little trouble and great and advantage; these oils being little inferior in virtues to those acquired by distillation, *per vesicam*; only for want of water, they are apt to prove empyreumatical; unless the fire be very cautiously regulated: which inconvenience is easily avoided in the other case. And after the same manner is pitch and colophony obtain'd in large quantities from vegetables, *per descensum*; *viz.* by placing proper parcels of fir-wood, for instance, upon a grate, and lighting a fire above, which drives their rosin or gum downwards into the vessel below.

*Corollaries from the history of vegetable oils.* 3. We may learn from the several preceding methods of obtaining the oils from vegetables, (1.) What their aromatic virtues properly are, and wherein they consist. The aromatic virtue of a plant appears to be some infinitely small quantity of matter, which we call its native spirit, lodged in the peculiar oil thereof. The oil itself is not the aromatic part of the vegetable; for the native spirit may be perfectly separated from that, which will then be left entirely destitute of its particular taste, smell, and specific virtues. And hence the expressed oils of spices are not so aromatic as those they afford by distillation. The ex-

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preſs'd oil of nutmegs is like wax, and without that ſtrong ſcent and taſte, ſo predominant in the eſſential oil. 'Tis the quantity of this preſiding ſpirit that ſets the difference betwixt the hot aromatic plants and the cold ones. Thus ſorrel and kali contain ſo little of it, that it ſeems loſt therein, or ſwallowed up by the abundance of acid ſalt, with which they abound. But ſuch plants are called aromatic, wherein the native ſpirit is ſo little obſcured, that it appears to be the predominating principle. There have been thoſe who pretended that this aromatic ſpirit was owing to the ſalt of vegetables; but in reality, that ſeems to have little or nothing to do with it; becauſe there are ſeveral plants which greatly abound in ſalt, yet have no aromatic virtue at all. (2.) What manner of action the ſun exerts upon aromatic vegetables. The common action of the ſun upon vegetables diſſipates their aqueous parts, renders their ſalts volatile, diſſolves their oil, and at length leaves little in them except their glutinous or fixed oil, and earth. But beſides this general action of the ſun, it appears to have the power of generating this aromatic or preſiding ſpirit in plants; for this is never found where there is no fire; and always in the greateſt plenty in the hotteſt climates. It may, indeed, reſide in the ſeminal principle of the plant; but 'tis always cheriſh'd, brought forwards, and increaſed by the heat of the ſun. There are few aromatic plants to be found near the north pole; but they grow plentifully, and in very great perfection, in the hot, ſouthern climates. (3.) Whence the balſams, roſins, gums, and tears or droppings of trees proceed. For the eſſential oil of vegetables being prepared from their nutriment, and lodged in proper cells during the winter ſeaſon; when the warm weather comes on, it is agitated, rarified, heated, made to burſt its cells, and ſweat out at the bark in form of an oil or balſam, which afterwards hardens into lumps of roſin, or gum, of particular ſhapes and ſizes, according to the nature of the ſubject, its juices, and the quantity that comes out at once: whence we are furniſhed with camphire, ſtorax, benjamin, labdanum, &c.

4. We now proceed to ſhew how many different kinds of ſubſtances are obtainable from one and the ſame vegetable by diſtillation, without the aſſiſtance of water. And to accompliſh this, we ſhall make choice of two ſubjects of different claſſes, under one or the other whereof all vegetables may, ſo far as my experiments reach, which were carefully made with this view, be commodiouſly ranged. The firſt is that of thoſe which afford a volatile, oleaginous, acid ſalt in diſtillation; and the other of ſuch as, contrary to the common opinion of chemiſts, yield a volatile, alkaline, oleaginous ſpirit by the ſame means. A general example of the former will be afforded us by *lignum vitæ*, and of the latter by muſtard-ſeed.

*Introduction to the next proceſs.*

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## PROCESS XXIX.

*Exhibiting the method of analysing, or resolving dry,* acid *VEGETABLES,* per se, *into their several component parts,* viz. *a* Water, *two kinds of* Oil, *a* Vinegar, *and a* Coal; *by an example in* Lignum Vitæ.

*The process.* 1. *FILL a glass retort almost to its neck, with the chips or dry shavings of guaiacum wood; apply a large receiver to the retort, lute the juncture with the common mixture of linseed-meal and water, and begin the distillation in a sand furnace, with a very gentle fire; augmenting it, by degrees, up to the strongest that can there be given: and thus there will be obtained, (1.) A large quantity of a clear aqueous liquor, or water. (2.) A red, and perfectly acid liquor, or spirit, tho' mixed with oil, and retaining something of an empyreumatical taste and smell. (3.) A light red oil, that will float on the top of the former water, or spirit. (4.) With a fire of suppression, that is, live coals being placed all around the retort, on the top of the sand, and the fire below raised to its highest degree, so as to make the sand glow; there will come over a ponderous, acid spirit, together with a black, thick, heavy, pitchy oil, that sinks to the bottom of all the former liquors. And, lastly, how great soever the fire be now made, there will remain behind a black, inodorous coal, (retaining about three parts in four of the original weight of the wood,) which, when applied to the fire, in the open air, flames and consumes away to insipid ashes.*

*With what cautions to be perform'd.* 2. The fire, at the first, should be no greater, than that one drop of the water may follow another, at such a distance of time as will allow us to count twenty; and this degree is not then to be increased, unless the distillation intirely ceases. The first increase that is made should only hasten the drops, so that ten may be counted in the space between their falling one after another; and thus we are to proceed gradually, till at last, by a fire suppression, the retort be made red-hot.

*The doctrine it affords.* 3. The acid spirit, which ascends along with both the oils, may be separated from them by the filtre; and the oils, left behind, be purified by the mixture of water, with which all acids readily unite. By this means the two oils may be brought together, and both the acid spirits united into one. If the vinegar, or volatile and acid spirit, thus distill'd and separated, be pour'd upon chalk, it strongly boils up therewith, and dissolves it; and if distill'd off from it, affords almost an equal quantity of an insipid water, with a large proportion of transparent oil floating thereon, which has now left its red colour, wherewith it tinged the spirit, behind in the chalk. But the chalk is only thus colour'd in its superficial parts; because, tho' the acid is readily drank into the pores

pores of that body, any thing which is unctuous cannot ſo eaſily paſs them, and therefore remains upon the ſurface. 'Tis the oil which thus tinges the ſpirit red; for if they are ſuffer'd to ſtand for any long time together, the oil will fall to the bottom, and leave the ſpirit above it limpid. Hence it appears, that oil and acid ſalts exiſt in vegetables, in the form of a ſoap; and that there are acid, oleaginous ſoaps, as well as thoſe which are alkaline and unctuous. And this is the reaſon of the great medicinal virtues of theſe acid ſpirits: 'tis their ſaponaceous nature that renders them ſo ſudorific, diuretic and penetrating, abſterſive, ſtimulating, and reſolving, as we find them; whence Mr. *Boyle*, and others, preſcribe them in the quantity of a dram, when any extraordinary motion is to be excited in the body. Indeed, they are excellent ſudorifics in peſtilential caſes: and *Paracelſus* declares, that an ounce of this ſpirit of guaiacum will have a greater effect in the venereal diſtemper than a pound of the wood, uſed in the way of decoction; but I have never made the experiment. Hence we alſo ſee what a ſmall quantity of latent acid there is in vegetables; ſince the chalk here employ'd, is very little augmented in its weight, by all that it drank in thereof. Yet this was ſufficient to keep the oil mix'd with the water in the form of an acid ſpirit; for when ſeparated, or detained in the chalk, the oil was ſet looſe, and floated freely on the ſurface of the water.

4. The oil which firſt riſes in the operation, is light and volatile, and approaches in its virtues to thoſe obtained by diſtillation with water, eſpecially if it be once rectified or diſtill'd off in the ſame manner as they; for by this means it will be ſeparated from its acid and and groſs part, and come over clear, thin, ſubtile, and of a beautiful red colour, without any diſagreeable empyreuma. Or the ſame end may be obtained, by diſtilling off this oil from a fix'd alkali. *Nature of the firſt oil.*

5. The thick, heavy oil, made to aſcend at laſt by a very violent fire, ſticks like pitch to the bottom of the receiver; and is more fetid and cauſtic than the former. The ſtronger fire has impreſs'd an empyreuma upon it; and the adhering ſalts have render'd it ſharp and corroſive. But by being rectified, *per ſe*, or with water, it loſes of its ill ſcent, and grows more mild and fluid, and comes nearer up to the nature of the firſt oil; from which it only differ'd on account of the greater change brought upon it by the fire, and its conſequent participation of more principles of the ſubject. *Nature of the ſecond oil.*

6. Hence we ſee, (1.) The tenacious or glutinous nature of water; which adheres ſo cloſely to plants, as not to be diſcovered in them after they are dry, till they come to be expoſed to the fire. If guaiacum, or any other durable wood, were kept for twenty years, or longer, and then diſtilled, it would afford a conſiderable quantity of water; tho' before the operation it appears to be abſolutely dry, and as hard as iron. Whence it ſhould ſeem, that water is neceſſary to be mix'd with the other principles of vegetables, in order to their preſervation; and that *Phyſical uſes of the proceſs.*

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to ſeparate it from them, would tend to the deſtruction of the whole concrete. (2.) The nature of the acid latent in vegetables; whoſe office it appears to be to preſerve them from corruption, and the worm, and render them firm and durable; to which end it is made ſtrongly to adhere to their oil, which prevents it from flying off. For if any wood, containing but a ſmall proportion of oil, be kept for ſeveral years, and afterwards diſtill'd, it will afford no acid ſpirit. This acid of vegetables differs from their fix'd alkali, as being generally more volatile than that ſaline matter which affords it. Thus recent *lignum vitæ* affords a large quantity of acid by diſtillation, and afterwards its fix'd ſalt by calcination; but ſome plants yield a volatile alkali firſt, and leave no fix'd ſalt behind. (3.) The nature and matter of ſmoke and ſoot, which are only the more volatile parts of the fewel, or the water, eſſential oil, and acid ſpirit of vegetables, made to aſcend together in vapor or fume, and afterwards condenſed into a light, ſoft, black, ſpongy matter, of great medicinal virtues, and affording a fine volatile ſalt by diſtillation. Whence we learn how the ſharp ſmoke of wood comes ſo greatly to affect the eyes and lungs. (4.) The reaſon of the method of drying and preſerving the fleſh of animals by ſmoke. For the acid ſalt of the fewel employ'd in the operation, being thus made to inſinuate into the pores of the ſubject, it prevents their corrupting; and, according to its own nature, turns them of a red colour; whence thoſe herrings, or other fiſh treated in this manner, are ſuppoſed to be the beſt cured, which appear the reddeſt. (5.) The ſeat and cells of the oil, the water, and the ſpirit in vegetables; which appear to the eye, by examining the coal. (6.) The nature and properties of *Helmont*'s everlaſting coal. *Helmont* pretends to a wonderful ſecret, ſo as to make a coal keep burning for ever, in the midſt of a moſt violent fire, without appearing to be at all conſumed; but, in reality, his method is no other than that of our preſent proceſs; whereby the remains of the ſubject may be kept ignited, without burning out, till air be let in upon them. And tho' this has been thought a ridiculous paradox in *Helmont*; yet I myſelf have, for the ſpace of three days and three nights, kept ſuch a coal, conſtantly urged with a very ſtrong fire of ſuppreſſion; after which it has ſtill remained black and unconſumed; tho' the leaſt ſpark applied to it in the open air, would inſtantly make it burn out, and reduce it to aſhes, which, unleſs the ſubject were green, would be almoſt inſipid.

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## PROCESS XXX.

*Exhibiting the manner of resolving dry,* alkaline VEGETABLES, per se, *into their component parts;* viz. *a* Water, *a* Spirit, *two kinds of* Oil, *an alkaline, volatile* Salt, *and a* Coal; *in the treatment of* Mustard-Seed.

1. *FILL a glass retort, almost up to the neck, with fresh, strong and ripe mustard-seed, that has been gently dried; and cautiously proceed to distillation in a sand-heat, with the same degrees of fire, as in the last process. Then there will come over, (1.) An acrid, fetid water, of a peculiar empyreumatic and cadaverous taste and smell; but neither acid nor unctuous. (2.) An unctuous spirit, perfectly resembling that of human blood, with a light yellow oil that floats upon its surface. (3.) With a fire of suppression, white fumes arise, which condense into a white, volatile, crystalline salt, like that of harts-horn, on the sides of the receiver. (4.) A thick, pitchy, resinous oil, that sinks thro' the other liquors to the bottom of the retort. (5.) A coal remains behind, as in the preceding process; which affords no fixed salt by calcination; but if farther urged with the fire, in the same close vessel, it becomes a fit matter for the making of phosphorus; tho' it affords a less proportion thereof than urine.* *The process.*

2. If the spirit which came over second, be again distilled with a gentle heat, it will yield a copious, volatile, alkaline or urinous salt, like that of animal substances. *Its nature and proper subjects.* And as for the oils, they may be separated and purified, as those in the last process; but instead of an acid, an alkaline salt will here constantly be found mix'd with them. That such salts should be obtainable from vegetables, without putrefaction, has been accounted a great paradox; as the way of doing it remain'd unknown to *Helmont*, and many other excellent chemists. And there are still some who pretend, that there is a certain fix'd salt in vegetables, which may be changed into an alkali by putrefaction; but absolutely deny that a volatile salt naturally exists in plants. *Wedelius* first taught how to obtain this volatile salt by putrefaction; but if we proceed in the manner of Mr. *Boyle*, which is that of our present process, we may readily obtain them from the proper subjects without it. Mr. *Boyle* was the first, that I know of, who obtained it from mustard-seed; as I myself have done from *Euphorbium*. But, indeed, it may be obtained by the bare action of the fire, without any putrefaction, from all the antiscorbutic plants, or those of the mustard, acrimonious, hot, or biting kind, which, by their effluvia affect the eyes, the nose, and irritate the parts so as to cause involuntary tears; such are onions, squills, garlic, leeks, horse-radish, scurvy-grass, cresses, hedge-

muſtard, rocket, the ſpurges, euphorbium, and, perhaps, all the poiſonous plants of *Africa*, when fully ripe, well dried, and in their perfection.

*Medicinal uſes of the production.* 3. The volatile ſpirit and ſalt of our preſent proceſs, are very heating, penetrating, aperitive, and approaching to a cauſtic nature, or that of fixed alkalies, but of contrary properties to acids. This makes them exceeding uſeful in medicine, where they ſupply the place of animal ſpirits and ſalts, as thoſe of harts-horn, urine, &c. in all caſes where the active principles of the body are languid; but not ſo where oils or ſalts already abound. Thus they are ſerviceable in phlegmatic conſtitutions, or the ſcurvy proceeding from an acid cauſe; as acids are in that which proceeds from a predominating alkali; in caſe of a lentor in the blood and juices, which prevent, or retard the digeſtion of the aliment, or its converſion into blood; and in ſmall obſtructions, or other caſes where there are no ſigns that the humors are already of too alkaline a nature; which may be known by a fetid breath, a ſcrophulous conſtitution, the corruption and putrefaction of any part of the body, or an univerſal *fœtor*; in all which caſes, acids are the remedies required.

*Medicinal uſes of the proceſs.* 4. Hence we have a juſt foundation for diſtinguiſhing all vegetables into two different claſſes; *viz.* thoſe which yield a volatile acid, and ſuch as afford a volatile alkali, by diſtillation; which diſtinction is abſolutely requiſite to our making a right uſe of the vegetable part of the *materia medica*, and employing it with any tolerable advantage, or ſafety in the practice of phyſic. All the plants which afford a volatile alkaline ſalt, are properly preſcribed in cold, pituitous caſes, where a fretting, corrupting acid, or muriatic ſalt abounds; but where the bile is too acrimonious, or the texture of the blood too much diſſolved and broke, or diſpoſed to putrefaction, they are by no means to be uſed. On the other hand, thoſe herbs which afford an acid ſalt in diſtillation, are properly ordered in all putrid or peſtilential caſes; and what is ſomething ſurprizing, even the venereal diſeaſe is beſt cured by acid vegetables, ſuch as the woods of ſaſſafras, guaiacum, box and juniper; but rendered worſe by alkalies: ſo that I cannot agree with thoſe, who would have the ſpecific cauſe of it to be an acid. I once had a patient ill of this diſtemper, in whom I was obliged to make uſe of vinegar and oil of vitriol, to prevent an univerſal putrefaction.

PRO-

## PROCESS XXXI.

*Exhibiting the four ways of separating distill'd* OILS *from their water, vinegar, salt, and spirit*; viz. *by the filtre, decantation, or inclination, absorpsion, and the separatory; with the method of purifying, preserving, and converting them into* ROSIN.

1. *CUT a piece of thin cap-paper into the form of a concave cone, moisten it with warm water, and place it in a glass funnel; then if a mixture of water, vinegar, or spirit, and oil, be poured into it together, all the former will pass through, and leave the oil behind; provided the paper be not suffered to dry, and the operation be stopped when the rest are run off. But if the paper were moisten'd in oil, then the oil itself wou'd first come through, and leave the water, spirit and vinegar behind. And this is the method of separating oils by the* filtre; *which we employ only when the oils are not very costly; because of the waste.* (2.) *When the oil to be separated is costly, but so light as to float on water, pour the mixture into a bellied glass, with a long and slender neck, and of such a size, that the liquor may perfectly fill it; then plunge the vessel in warm water, to dissolve or liquify the oil, and make it all rise to the top; so that by gently inclining the glass, it may be poured off pure from the other liquors into a vial; but if any oil still remains behind in the glass, pour hot water into it, whereby the oil will be made to ascend to the neck; and thus it may be separated, even to the last drop.* (3.) *When the rich oil is heavy and sinks in water, let the other fluids be first grosly pour'd off from it; then fill a bellied vial, that has a slender neck, with the oil and the liquor that adheres thereto, and place it in some warm water, to dissolve the oil from the sides of the vessel; by which means, also, the lighter parts of the mixture will be forced from it, and swim upon the surface thereof, so that it may easily be imbibed, and clean taken off, by degrees, with a wreathe of paper, first moistened in water, and squeezed out at every time, so as to leave the oil pure, in the belly of the glass.* (4.) *Or else, in general, we may make use of the* separatory, *which is a bellied glass, that rises with a narrow neck, but descends in a slenderer, conical tube, perforated at the end; into which the mixture being poured, the oil will settle at the top, if it be light, or fall to the bottom, if it be heavy. In the former case it may be decanted, or else the lighter parts being suffered to run off from it, the oil at length may be stopp'd in the slender shank, by applying the pulpy part of the hand or finger fully and closely to the upper orifice, to hinder the current of the air, and afterwards suffering the oil to run into a different vessel; or if the oil fall to the bottom of itself, it may be permitted to run out first; the course of the other liquor being prevented as before. And here also the oil that adheres to the sides of the glass, may be wash'd and* *The process.*

*melted down by hot water. But great care ought to be had in thus separating essential oils; for unless they are made very pure, and entirely freed from their water, spirit, or vinegar, they easily corrupt, and grow mucilaginous, or mouldy.*

*Cautions and direction relating thereto.*

2. When the essential oils of vegetables have thus been thoroughly depurated, 'tis very useful to mix a few drops of pure spirit of wine, rectified without the addition of alkalies, with every ounce of them, in order to preserve and keep them in perfection. Some late writers have observed, that alkalies take off from the fragrance and peculiar flavour of these oils; and, indeed, they seem opposite to the native spirit of vegetables, which resides in their essential oil. But spirit of wine, prepared without the assistance of any fixed alkaline body, will prevent our oils from degenerating, or running into rosin, and defend them from that rancid taste, mouldiness or ropiness, which a little water left among them would, otherwise, soon occasion; after itself is once corrupted.

3. These essential oils, whether light or heavy, ought to be kept in glasses exactly closed; otherwise their subtile part, or distinguishing spirit exhales, whence they become tasteless and inodorous, and scarce knowable from one another. And thus too, by shaking them well with warm water, this will become sapid, odorous and milky, as the oils lose their peculiar taste and smell; and if the operation were frequently repeated with such water, they would at length lose all their force; and those which were different oils at first, appear as one and the same.

*Nature of the productions.*

4. All oils are thicken'd in their consistence, by age, heat, or repeated distillation; and at length, after some years, by bare rest, come to appear in the form of balsams, or rosins. Thus, having once rectified some oil of turpentine, in high vessels, till it appeared like pure alcohol of wine, in order to preserve therein some very curious anatomical preparations, I found my oil, after some years standing, was grown as thick as turpentine itself; and, like that, had cased over the surface of my preparations with a kind of varnish. Yet during the whole time, the containing vessels remain'd close cover'd; so that none of the more fluid parts could escape. Nor can it be objected here, that the oil, like a menstruum, had dissolved some of the glutinous parts of the animal substances it was design'd to preserve; for this was far from being the case. And it will alter its consistence in the very same manner, when suffered to stand alone. If it were not for this disposition of oil of turpentine to grow thick with keeping, whereby it gives a coat to whatever is lodged therein, it would far exceed spirit of wine, in preserving anatomical preparations; because it never frets off the *epidermis*, as the other constantly does.

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## PROCESS XXXII.

### *Exhibiting the manner of resolving* Balsams *into* Vinegar, *two kinds of* Oil, *a* Rosin, *and* Colophony; *by an example in* Turpentine.

1. M*ELT native turpentine, over a gentle fire, till it flows like water, and carefully pour it through a hot funnel, into a glass retort made warm to receive it, so that no part thereof may stick in its neck,* * *and the retort remain but two thirds full; then lute on a receiver, and cautiously begin the distillation in a soft sand-heat, increasing the fire by slow degrees; and there will come over,* (1.) *A pellucid and gratefully acid spirit, or vinegar, which will mix with water; then the fire being a little raised;* (2.) *A fine, limpid, subtile, penetrating, and aromatic oil, the lightest of all fluids, except spirit of wine; whence it has obtained the name of ætherial oil. This ascends, mix'd with an acid spirit.* (3.) *What now remains behind in the retort, is a viscous, transparent, red substance, or rosin, which is inflammable in the fire, soluble in oil, or rectified spirit of wine, but will not mix with water; it also grows hard in the cold, liquifies with a small degree of heat, is very penetrating, and capable, by mixing with the oil and vinegar before separated from it, of being reduced to turpentine again.* (4.) *With a fire of suppression, there will ascend, whilst the matter crackles in the retort, a very red oil, mix'd with acid spirit; and at last a blackish, thick, fetid, heavy one, which sinks through the other liquors to the bottom of the receiver; having almost the same consistence with the turpentine itself.* (5.) *There now remains behind a transparent body, call'd colophony, which, when cold, is as brittle as glass; but capable of melting with a small degree of heat. Colophony is no more than rosin, boiled till it becomes very transparent and brittle, so as sometimes to crack spontaneously. It therefore differs from rosin, only in being less viscous, less easy to dissolve, but harder and more brittle, when cold.* *The process.*

2. This process will produce the same effects, and exhibit the same phenomena, in all sorts of balsams; as those of *Mecha*, *Gilead*, &c. which all formerly went under the name of turpentines, as we learn from *Theophrastus*. I have perform'd it upon a great variety thereof, and could never find any thing alkaline or inflammable to rise first; but con- *The cautions it requires.*

* When the neck of a retort is too long, or its orifice too small to receive the subject, without the use of a funnel, or without loss of time in getting of it in, 'tis usual to take off a part of its neck, and so make a wider orifice, by means of a ring of iron, made glowing-hot in the fire, and directly applied to the nose of the retort, so as exactly to fit it all round, which will make the glass crack, and break off in the part desired. The same end may likewise be obtain'd, by tying a thread tight about the part of the glass to be cut off, that has first been rubb'd over with sulphur, and then setting fire to it.

stantly.

ſtantly a ſpirit that would make an effervescence with alkalies. The fire muſt be made very gentle at firſt, in order to obtain this ſpirit; for otherwiſe it will be loſt, or never appear diſtinct. All manner of genuine balſams and turpentines liquify with a ſmall degree of heat; and may be reſolved into their ſeveral principles by diſtillation; but 'tis otherwiſe with wax, which is eſteemed a ſpecies of balſam. The ſubject is firſt melted for the convenience of pouring it into the retort, without touching the ſides; for if any part ſhould ſtick in the neck, it would preſently be driven over into the receiver; without any ſeparation of parts. And this is alſo a reaſon for heating the receiver; *viz.* to prevent the turpentine from ſticking to its ſides; as alſo to keep it from being crack'd by the hot balſam. Care alſo muſt be had not to fill it too high with the ſubject; for in that caſe a flatulent matter riſing from it, is apt to break the glaſs in the time of diſtillation.

*How performable to advantage.* 3. Recent turpentine may to much greater advantage be diſtill'd *per veſicam*, with a large quantity of water; by which treatment it will afford the ſame productions, in the ſame order. And this is the method commonly practiſed by the druggiſts, to obtain oil of turpentine in large quantities, with expedition; for the refrigeratory uſed in diſtilling by the alembic, greatly quickens the operation. And the boiled turpentine remaining at the bottom of the ſtill, is what they ſell for roſin; and which being for a conſiderable time kept in an open veſſel, will at length turn to colophony.

*Virtues and uſes of the productions.* 4. The grateful, acid ſpirit, or vinegar, which firſt comes over, is, when purified from the other principles, highly refrigerating, aperitive, diuretic, ſudorific, balſamic, or preſervative from putrefaction; and one of the beſt medicines we have in nephritic caſes, eſpecially when the ſtone is lodg'd in the kidneys, or ureters; and for quenching thirſt. It appears to be the ſame production as we firſt obtain, by diſtillation, from *lignum vitæ*; but it retains much leſs of the empyreuma than that. All kinds of balſamic woods afford an acid ſpirit, which is the volatile, oily ſalt of the vegetable; whence it appears very probable, that the acid ſpirit of guaiacum is of the ſame nature with the firſt ſpirit of this proceſs; being afforded by the balſamic or terebinthinous parts of that wood. Accordingly, if mix'd with water, and injected, glyſter-wiſe, in a *gonorrhœa virulenta*, 'tis an admirable medicine; and of very great ſervice in caſe of venereal ulcers, ſpots, and puſtules.

5. The fine æthereal oil is an admirable diuretic, healing, relaxing, diſcutient, anodyne, ſtyptic and balſamic medicine. Its diuretic virtue is ſo great, that if only a ſingle drop of it be drank along with any other liquor, it will, in the ſpace of a quarter of an hour, give the ſcent of violets to the urine; and would have the ſame effect by being barely rubbed upon the abdomen. We have an extraordinary inſtance of its diuretic virtue, in an accident that befel an apothecary's ſervant in *Holland*, who, miſtaking a bottle of this oil for ſome other drinkable liquor, took a draught thereof to quench his thirſt; upon which he ſoon after fell

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into a diabetes, attended with a violent *profluvium seminis*, that proved exceeding difficult to ſtop; and left an ill effect behind it, which the perſon felt all his life after. Hence, tho' it may, when properly uſed, be ſerviceable in the venereal diſeaſe, yet being apt to over-relax the veſſels, it requires a deal of caution in the management; and thoſe of a tender and delicate conſtitution may ſuſtain great damage by an unskilful uſe thereof. 'Tis obſervable of this oil, that being ſhook together with the acid ſpirit which riſes at the ſame time in diſtillation, they will make for a ſeaſon a milky mixture, like oil and water; but the oil preſently frees itſelf, and mounts to the top. Whence it appears, that ſome of thoſe principles which were united in a vegetable cannot be brought into conjunction again, after they have once been ſeparated. And as this oil will not mix with water, it appears not to be of ſo ſubtile a nature as pure ſpirit of wine. This oil has ſuch a power to heat the body, that whoever anoints the extremities of it therewith, may travel unhurt by the froſt of the coldeſt countries. It alſo reſtores the limbs of ſuch as have been frozen; and if externally uſed, by way of prevention in the winter-ſeaſon, keeps the feet and hands free from kibes, chaps, and chilblains; as it excellently cures them, after they are perfectly form'd. And internally taken in the quantity of a few drops, it has the power, upon account of its warmth, to put by the cold fit of an ague. And in all caſes where the tendons are ſhrunk and contracted, or the limbs are withered, dry'd up, and render'd ſtiff or immovable by wounds, fractures, *&c.* this oil has ſuch a relaxing virtue, that being rubbed in upon the part twice a day, with a warm hand, before the fire, it greatly conduces to reſtore them to their natural ſtate. It is ſo diſcutient too, that being rubbed upon cold or hard, ſcirrhous or cancerous tumors, in the glandular parts of the body, it will reſolve them, bring them down, and diſperſe them. 'Tis likewiſe a moſt incomparable anodyne, and, perhaps, the beſt that is afforded us by chemiſtry; for when applied hot to any lacerated or mangled nerve, tho' the pain be ever ſo great, and the ſymptoms ever ſo threatening, it ſoon ſtops them all, like a charm, and gently conſtringes, criſps up and warms the injured part, and preſerves it from corruption. The ſtyptic virtue of our æthereal oil is ſo great, that it ſtops a hæmorrhage like an actual cautery; for which reaſon 'tis uſed by chirurgeons in caſes of amputation, where the large blood-veſſels are cut aſunder. For pledgets dipp'd therein, being applied ſcalding-hot to the mouths of the bleeding arteries, it proves very effectual in cloſing them, at the ſame time as it defends them from farther injuries; as inflammations, gangrenes, *&c.* Laſtly, this oil is no leſs remarkable for its balſamic virtue, than for all the reſt. Any vegetable inſect, or fœtus ſuſpended in it, may be preſerved unaltered, or uncorrupted for a great length of time. Even the human body, if twice or thrice dipt therein, then ſuffer'd to dry for a few days in the open air, and afterwards dipt, and dry'd again for ſeveral times ſucceſſively, may, by this

means,

means be kept, as it were in case of glass, for many ages, without altering its external form, or appearance. This method of embalming was unknown to the *Egyptians;* and far exceeds all those they were possessed of. Yet this is not without its inconveniencies; for the smell of the oil is unpleasant; and, besides, 'tis very apt to be sully'd and obscured by any dust that shall fall upon it: and, in time, it returns to turpentine again; bating for the loss of its acid spirit.

6. The thick red, or blackish, viscous oil, which comes over last, is, upon account of its consistence, less tractable than the former; and not so rich in medicinal virtues: tho' in some degree it abounds therewith. If this be mixed with spirit of nitre, it makes an explosion, and turns to flame.

7. There appears to be no very great difference between the rosin and the colophony of our present process. If the rosin be used internally, it seems to act much after the manner of turpentine; proving diuretic, and presently giving a violet smell to the urine. On account of which penetrating virtue, turpentine is scarce inferior to any other native balsams for medicinal purposes. But colophony is, on some accounts, preferable to rosin; as, particularly, in long preserving the bodies of vegetables, insects, or other animals unaltered; for which purpose it serves almost as well as amber. We are beholden to Mr. *Boyle* for this discovery; who tells us to melt our colophony gently, and then to dip our subject therein, as it hangs pendulous from a thread, and soon take it out again to cool; whereby it will gain a case, which by repeated immersions may be increased to what thickness we please. So that a beetle, a lizzard, or a frog, for instance, may thus be made to appear as if it were included in a lump of amber. But such preparations ought to be kept in a place free from dust; otherwise the colophony will be cover'd over therewith, and lose of its transparency. Colophony, also, is an incomparable remedy to cause a cicatrix in the nervous, membranous, and bony parts of the body, when they are laid bare. For when well boiled, it may, after 'tis thoroughly cooled, be reduced to a most subtile powder, which being strewed upon such wounded parts, will have a very great effect in healing them up. When applied in this manner, and only covered over with clean, dry lint, itself presently dissolves, prevents the rise of fungous flesh, excellently defends the bone from being corrupted or fouled by the matter, or corroding ichor of the wound, fills it up with solid flesh, and skins it over. Where the small membranous vessels, or nerves of the body are cut or bruised, no better medicine can be employ'd; and I could scarce ever cure contusions on the *tibia* without it: for when the bone is here laid quite bare, plaisters are apt to cause much mischief. In all wounds of the periosteum, it has never fail'd me once. It constantly heals without suppurating; and I have performed many extraordinary cures by its means, even in old, stubborn ulcers, where 'tis very difficult to induce a cicatrix, and prevent a relapse.

8. Hence

8. Hence we may learn, (1.) That a volatile acid salt, or spirit is lodged in all the native balsams of vegetables. (2.) That this salt may be so dissolved in the oil of the balsam, as to appear one body therewith. (3.) That balsams change into oil, when deprived of their acid and rosin. (4.) That balsams change into rosin, when deprived of their acid and oil. (5.) After what manner the several degrees of the sun's heat act upon oils, balsams, rosin, and pitch. (6.) And lastly, why those trees which are green in the winter, abound most in balsam. For all ever-greens, as the pine, the fir, the yew, the box, the savin, the juniper-tree, &c. stand in need of a greater quantity of oil, or balsam, to entangle and hold in the vivifying, acid spirit, which is the cause of their perpetual greenness; whilst other vegetables, which wanting this acid, are not so full of balsam, languish and wither in the winter season. *Corollaries from the process.*

## PROCESS XXXIII.

*Exhibiting the manner of resolving dry* BALSAM, *collected by animals, into an* acid Spirit, *and a* Butter, *or* Oil; *by an example in* WAX; *the only known production of that nature.*

1. *HALF fill a glass retort with fine wax, cut into pieces small enough to enter the mouth thereof, throughly dissolve it with a gentle heat, and pour clean, dry, and warm sand upon it, to fill the remaining part of the retort up to its neck; then lute on a receiver, and proceed to distillation, in a sand-furnace, with a gradual fire. There will come over, (1.) an acid spirit, of a very nauseous taste, and a peculiar, fetid, and empyreumatical smell; something like what ascended first in the distillation of turpentine; but more disagreeable to the palate; (2.) upon raising the fire, an oil, or butter that will congeal in the cold; and generally appears white. (3.) And with a fire suppression, the whole remaining quantity of the wax, which appears in the form of a butter.* *The process.*

2. In the last article, that of rising entirely in distillation, wax differs from all other balsams, which may constantly be resolved into their principles; and always leave some feculent, or terrestrial part behind them. The oil, or butter, is likewise singular in this, that it loses nothing by repeated distillations, but becomes every time more thin and limpid, without depositing any fæces; whereas all other oils constantly grow thick and foul, and leave an earth behind them by cohobation. But the butter of wax, distilled over three or four times running, appears like oil of turpentine, and will not congeal, grow foul, or deposite a sediment. *Its nature.*

*Nature of the Subject.*

3. Wax appears to be no more than an unctuous humor, sweat out at the pores of vegetables, and lodged in small quantities upon the surface of their leaves and flowers; where 'tis afterwards thicken'd by the sun, and scraped off by the rough feet of bees, which are the only animals fitted for that purpose: and these barely collect and scrape it off from plants, for their particular uses, and carry it in their feet to their hives, without receiving it into their bodies, or, perhaps, so much as their gorge. If we examine a piece of rosemary with a microscope in the summer, we shall find its leaves cover'd over with yellow globules, which are the wax, that causes them to feel rough and clammy, or stick to the fingers when touched. Whence we may learn, that many fabulous things have been told us of wax, by some writers upon the *materia medica*; and that in reality it does not belong to the class of animals, but vegetables. Indeed, it seems to be a kind of camphire, like which, upon distillation, it leaves no fæces, but proves perfectly volatile; and grows white by being boiled in change of water.

*Doctrine of the Process.*

4. Hence we see there are balsams, or oils lodged in vegetables, which may be totally raised in distillation, without suffering any separation in their parts, and yet retain their oleaginous nature; which renders the notion of camphire more familiar to us. And, indeed, there may be a great difference between the ways wherein oils are lodged in plants.

*Medicinal virtues of the productions.*

5. The rectified oil of wax is possessed of great medicinal virtues; being of a nature between the expressed oils of seeds, and the æthereal oil of turpentine. 'Tis emollient, laxative and anodyne. When carefully wash'd, and depriv'd of its ill scent, or acid spirit, by shaking it with water, 'tis an excellent remedy; being used externally, in cases where the limbs are dry, stiff and inflexible; or where the juices are thicked and condensed, so as to form hard tumors; for it wonderfully supples, relaxes and dissolves. In *France* they have found it very effectual in case of costiveness, attended with severe pain; for the relief whereof they only anoint the abdomen with it; which so mollifies and relaxes the fibres, as to procure an easy passage to the excrements downwards. 'Tis likewise an extraordinary remedy for chilblains, chapped nipples, and all cracking and dryness of the skin, whether of the face, lips, hands or feet; provided, as was said before, it be first well wash'd with warm water, which will dissolve and take up its acid part, and clear it from any adhering sordes.

PRO-

## PROCESS XXXIV.

*Exhibiting the manner of preparing,* Elæoſacchara, *or* Sugar-balſams; *with the productions of the preceding Proceſſes.*

1. *TO eight parts of the fineſt, dry, loaf-ſugar, reduced to powder, add one, of any eſſential oil, and grind them together, in a cloſe marble or glaſs-mortar, for a conſiderable time, ſo as perfectly to incorporate them into one body, or* Elæoſaccharum; *which is to be kept in a dry, clean glaſs, cloſe ſtopped, and defended from the air.* *The proceſs.*

2. If the oil be ſtrong, or violently hot, as that of cinnamon, for inſtance, eight drops of it may be ſufficient for an ounce of ſugar; for both its ſcent and taſte are greatly augmented by the operation, if perform'd in a mortar that is cloſe, to hinder the avolation of its fine, fragrant, aromatic parts. And if this be done, the longer the operation is continued the more perfect the medicine will be. *How performable to advantage.*

3. How eaſy and ſlight ſoever this proceſs may appear, its uſe is very extenſive; as teaching us the way of converting oils into ſalts. The ancients, who were unacquainted with ſugar, and the method of diſtillation had, nevertheleſs, their μέλι-ἔλαιον, or honey-balſam, inſtead of our *elæoſaccharum*; but could never prepare it to the advantage that we do; they being obliged to uſe oils by expreſſion, for thoſe we gain by diſtillation, which contain the moſt medicinal part of vegetables. But theſe being of themſelves too fiery to be truſted alone to mix with the juices of the human body; this proceſs ſhews an admirable way of converting them into a ſoap of great medicinal virtues, which may be very commodiouſly adminiſtred, and with all deſirable advantages. By this means we can, at any time, preſently mix any eſſential oils with water, wine, or what other liquor we pleaſe, and ſo render them potable, without at all impairing, nay, in reality, greatly improving their virtues. And when once ſuch a medicine is prepared, it may long be kept in poſſeſſion of its full virtues, tho' carried into the remoteſt regions; being commodiouſly portable, and at all times fit for immediate ſervice. *Its excellence and uſefulneſs.*

4. 'Tis a common opinion, that ſugar is prejudicial to the body; but whoever conſiders the nature of it, will find it poſſeſſed of many excellent medicinal virtues; and that, like all other wholeſom things, it proves hurtful only when uſed too freely. It appears to be the eſſential, or native ſalt of the ſugar-cane, mix'd with a certain proportion of oil, which renders it inflammable. It melts at the fire, diſſolves in water, and is ſapid; conſequently it poſſeſſes all the properties of a ſalt: ſo that it ſeems to be an unctuous ſaline body, or a kind of natural ſoap. I am therefore *Nature of the Subjects and Production.*

fore surprized that any physicians should give into the common opinion of its being unwholsom, or filling the body with phlegm, or other ill humors; for it certainly resolves, relaxes, attenuates, and proves serviceable in all distempers proceeding from a viscid cause; and is able to dissolve any glutinous, gummy, or oleaginous substance in the body; so as to render it easy to unite and be carried off along with the more aqueous juices. 'Tis on this account that it conduces to take down the unwieldy bulk of fat, gross habits, or over-fleshy persons; and proves of disservice to such as are too lean and meagre. Thus also, in the tender bodies of infants, it may, when used too freely, bring on the rickets, by over-relaxing the vessels, and dissolving the humors. It is, indeed, prejudicial to the teeth, as being a kind of sharp, penetrating salt; and if applied to the naked nerves, or carious bones, sometimes causes intolerable pain. But, to speak freely, there is no vegetable substance whose nature is harder to determine than that of sugar. It cannot properly be called a salt, because it burns all away in the fire; not an oil, because it readily mixes with water; not a soap, because saponaceous salts can hardly be brought to ferment, as this easily may; after which it affords an inflammable, inebriating spirit, by distillation; but when crude, an acid one, capable of extinguishing fire. It also dissolves in the open air, and runs into a syrup, that by straining becomes transparent; and what is more surprizing, afterwards shoots into crystals. 'Tis not only saponaceous it self, but, as we find, has also the faculty of turning oils to soap. If this were done with fixed alkali, and in the distill'd oils of vegetables, they would lose all their fragrant scent and taste by the mixture; both which are improved by uniting with sugar. It is also easy to separate and recover the essential oil from the sugar, wherewith it was thus mixed, by pouring warm water to the elæosaccharum, and distilling it off by the retort, or alembic. All saponaceous bodies have the faculty of dissolving oils; whence we may learn, that sugar is of a saponaceous nature; for by being ground, and thoroughly united with them, it breaks their parts so fine, that they will now take away, or wash out with water, such spots in garments, as they would before occasion. Thus we see that distilled vegetable oils, when once, by fermentation and distillation, reduced to inflammable spirit, will no longer leave their marks upon cloths.

*Use of the process.*

5. With elæosacchara, prepared after the manner of the present process, we may make a variety of medicines, suitable to the various intentions of the physician, and endowed with the medicinal virtues of what plant we please. Thus, in order instantly to obtain a rich cordial, to support a person under the greatest depression, or even in the agonies of death, dissolve a little of the elæosaccharum prepared with the essential oils of cinnamon and orange, or citron-peel, in cinnamon-water, and this will directly afford it*.

* This process might furnish the shops with much more effectual medicines than are commonly sold in them; and 'tis pity the hint should have been taken by illiterate tradesmen and empirics, sooner than by regular physicians.

PRO-

## PROCESS XXXV.

### *Exhibiting the manner of preparing* MEDICATED LIQUORS, *with the productions of the preceding Processes.*

1. TO *one part of any* elæosaccharum *add two parts of the medicated salt of* Tachenius; *grind them together in a marble mortar, and, by degrees, pour upon them sixteen times their own quantity of the distill'd water, by fermentation, of the vegetable that afforded the oil for the* elæosaccharum; *so as to make a perfect solution, or* Medicated Liquor. *The process.*

2. Such a mixture as this will contain, to great perfection, all the active and particular virtues of the plant united together; whence it is exceedingly useful in medicine, and the noblest, or most powerful remedy that can be expected from vegetables, in the most suitable and convenient form. *Its usefulness in medicine.* 'Tis made up of the essential oil, the salt and spirit of the subject, which being all the parts possessed of any particular medicinal virtues, are here concentrated, or brought together into one whole. The elder *Helmont* having observed, that chemistry had invented a medicine capable of dissolving all foreign matter in the body, and strengthening the fibres, adds, "But, if we cannot attain to such a secret, it may be "sufficient that we make an oily salt; which will have almost the same "virtues with the other; and, by uniting the salt of cinnamon with its "oil, by a secret circulation, we may obtain an extraordinary medi-"cine." In imitation whereof, I contrived the present process, which will furnish us with such remedies, as I had rather physicians should occasionally make experiment of, than implicitly believe the characters I cou'd deservedly give them. Thus, to make an effectual medicine in case of the colic, from a cold cause, take a dram of the *elæosaccharum* of fennel, two scruples of the fixed salt of the same; or, because that wou'd come dear, of any other vegetable; for, 'tis the same thing, as we formerly observed; and six ounces of the distill'd water of fennel, by fermentation, mix them together for a liquor to be taken in the quantity of half an ounce every half hour, or oftener, if there be occasion. The *elæosaccharum* of savin, treated in the same manner, affords an admirable emmenagogue, or medicine to promote the menstrual flux; that of tansy, or wormwood, one to destroy worms in the body; that of cinnamon, another to cure the green-sickness and hysteric diseases; that of turpentine, tho' difficult to mix, an excellent medicine, in case of nephritic complaints, *&c.* After the same manner an incomparable febrifuge may be prepared for stubborn agues, from the *elæosaccharum* of wormwood, or carduus; which, in my practice, has perform'd extraordinary cures.

3. The

*Virtues and uses of the production.* 3. The dose of these medicated liquors, and the repetition thereof, must be proportion'd to the demand of the distemper, and the strength of the distilled oil employ'd in their preparation. Thus, a small spoonful of that prepared from the hot aromatic oil of cloves, is a sufficient quantity to be taken at once. In general, they ought to be taken upon an empty stomach; and the dose repeated every hour, or oftener. In case of an intermitting fever, my method is to give the medicated liquor of wormwood, in the quantity of a spoonful, or more; beginning an hour or two before the fit is expected; and repeating the dose once in a quarter of an hour, whilst the patient keeps sweating in a warm bath, and waiting for the paroxysm. This method will cure the most stubborn tertian, unless it be deeply rooted indeed, or proceeds from a scirrhosity, or suppuration in some part of the body. Thus, likewise, in an obstruction of the *menses*, the medicated liquor of rue, given in proper doses, at due distances of time, for three or four days together, before the accustom'd period, will, with the assistance of a warm bath, used an hour before bed-time, cause them to flow regularly.

## PROCESS XXXVI.

### *Exhibiting the manner of preparing sweet-scented, or* apoplectic BALSAMS, *with distill'd* VEGETABLE OILS.

*The process.* 1. *TAKE eight parts of perfectly pure pomatum,* * *two of clean white wax, and one of any odoriferous essential oil; dissolve the two former together in a glazed, or porcellane vessel, over a very gentle fire, and, after the vessel is removed from thence, add the oil, mix them all well together, and, when the whole is perfectly cold, it will congeal into a balsam, which is immediately to be put up into pure vessels of glass, lead, or silver, and kept close from the air.*

*The Cautions wherewith it should be perform'd.* 2. The essential oil ought not to be added before the mixture of the wax and pomatum begins to cool, lest some of its volatile, or most odoriferous parts should, by the heat, be made to fly off. And, after the three ingredients are thoroughly incorporated together, the containing vessel may be plunged into cold water, to hasten the congelation, prevent any farther evaporation, and to render the balsam the stiffer, and

* The art of making pomatum, in perfection, so that it shall appear extremely pure, stiff, white, and porous, is no inconsiderable secret, and lies in few hands. The unguent, which now commonly goes by this name, is a different thing from that we commonly find described in dispensatories; as being prepared without any apples, or pome-waters. It may, if a person has the secret, be made to great advantage, with little trouble.

fitter

fitter for keeping. A quantity of *elæosaccharum*, containing the due, specified proportion of oil, may here be conveniently substituted for the oil itself; but when the oil is very odoriferous, or highly aromatic, its quantity need not exceed that of half, or even a quarter of what is ordered in the process. The proportion of the wax may likewise be diminished, where the balsam is required of a soft consistence, or design'd to be long kept, or in a cold climate: for the wax, renders the balsam durable, in proportion to the quantity employ'd, but at the same time takes off from its odour. The pomatum ought by all means to be fresh, no way discolour'd, but perfectly white, and without any ill scent.

3. These balsams may be made of any colour one pleases, by the addition of a proper pigment: for as they are designed only for external use; we have no ill consequence to fear from the tinging ingredient, provided it be not a subtile poison: thus a few grains of gum-lac, rubbed fine with one or two of sal-ammoniac, or a little native cinnabar, subtily ground, and mixed with an ounce thereof, will make them appear of a beautiful red; without changing either their scent or taste. Verdigrease, or the pigment made of the juice of buck-thorn berries, will give them a very fine green; and saffron ground fine, a gold colour: but this will alter their scent; and therefore gamboge ground with a very little sal-ammoniac, to take away its clamminess, or the powder of turmeric-root, may be used in its stead. And by this means we may suit the colour to that of the oil of the plant made choice of for our balsams. The general method of tinging them, is this. When the wax and pomatum have been melted together, removed from the fire, and begin to grow cold, cast in your pigment, well prepared, or ground fine in a mortar, and mixed with a little pomatum; then keep the mixture stirring, to incorporate all thoroughly together; and soon after add the aromatic oil, and blend the whole into one uniform and consistent mass; keeping it in motion till it grows perfectly cold. *How it may be varied.*

4. As these balsams are designed only for perfumes, to refresh the spirits, and add vigor to the nerves; those oils ought to be employed in their preparation, which may most conduce to that end. Such are the essential oils of cinnamon, orange-peel, cloves, lavender, nutmets, mace, *Indian* cedar, rhodium, marjoram, baulm, origanum, roses, jasmin, and the *Philadelphus Athenæi*, the scent whereof is exceeding grateful, and beyond that of jasmin-flowers. The expressed oils best fitted for this process, are those of mace, and nutmegs, the opobalsamum of *Arabia*, for we have none that comes from *Syria*, and the white *Peruvian* balsam, which has a very delightful fragrance. *How performable to the best advantage.*

5. The *Italians*, who are thought to prepare these balsams in great perfection, and do it principally for the use of the duke of *Florence*, who makes rich presents thereof to foreign ambassadors, chuse some essential oil; as that of nutmegs, for the basis of their compositions. But this they shake, and wash so long in water, that it loses all its pecu-

liar odour; which is so far from being of any advantage to the balsam, that it doubtless proves a disservice thereto. For, as we formerly observed, whenever an oil has lost its specific scent, it cannot be distinguished from any other common, unctuous, or fat substance.

*Origin of the name.* 6. The word balsam is of *Hebrew*, *Chaldee*, or *Arabic* extract; and from thence transmitted to the *Greeks* and *Romans*, as we learn from *Florus*, who tells us, that "the *Roman* army met with *balsams*, in their "passage through the odoriferous groves of *Asia*." Balsam, in *Hebrew*, is called בער שמן, *Baal Shemin*, the prince of oils. All balsams took their names originally from that of the valley of *Hieruchuntum* in *Syria*, where it is found to this day, and called *Opobalsamum*. This is mentioned by *Theophrastus*, *Josephus*, and others. The genuine balsam, or *Opobalsamum* itself, is so exceeding precious, that the whole stock of it is appropriated to the service of the grand *Seignior*; that person being adjudged guilty of a capital crime, who shall transport any part thereof to foreign countries. Our merchants bring away the balsam of *Mecha*, instead of the *Opobalsamum*; only mixing it with a proper proportion of the balsam *Copaiba*, to give it a flavour.

*Medicinal uses of the production.* 7. These balsams may be of use in hysteric cases, in the palsy, apoplexy, and lethargy, arising from a cold cause; for, when smelt to, they are found wonderfully grateful and refreshing. That prepared with the distilled oil of rue, is most proper for hysterical disorders; that of lavender, for apoplectic, and other cephalic cases, &c.

* These are the balsams, or perfumes, which people commonly carry in their pockets, included in little silver, or ivory boxes, or the heads of their canes, to smell to occasionally; and may be suited to every constitution, so as to prove grateful and agreeable, even to those who have an aversion to the luscious sweets of musk, civit, and ambergrease.

INTRO-

# INTRODUCTION
## TO THE
# HISTORY
## OF
# FERMENTATION.

## PROCESS XXXVII.

*To ſhew that all kinds of crude* MEAL *and* MALT, *ſteeped in water, will not, without a previous* FERMENTATION, *afford a ſpirituous, or vinous liquor, by diſtillation; but only one that is almoſt ſcentleſs and inſipid.*

1. M*IX any kind of meal, or ground malt, with warm water enough to make it of the conſiſtence of panada, and diſtil the mixture by the alembic, with a gentle heat: what comes over will be only an inſipid, uninflammable water, with very little ſcent, and capable of extinguiſhing fire.* *The proceſs.*

2. The vapor raiſed in the operation condenſes into drops, like dew, in the head of the ſtill, and does not preſently run down in veins to the worm. The water which thus comes over, is not perfectly pure and ſcentleſs; becauſe all vegetables contain ſomething of a ſubtile, tho' uninflammable, native ſpirit; as we learn from our firſt proceſs; and ſome part hereof is retained in the meal or malt: but if the liquor be drank, it has all the effects of water; and not any one of wine. *Its nature.*

3. Hence it appears, that what is called the *firſt fermentation*, or the reduction of any grain into malt, will not fit it to afford an inflammable ſpi- *The doctrine it affords.*

rit by distillation; another fermentation with liquids, being absolutely requisite for that purpose. And this holds equally true of all kinds of pulse and grain.

## PROCESS XXXVIII.

*To shew that* Honey *made into hydromel with water, affords no spirituous liquor, whilst it remains* CRUDE, *or* UNFERMENTED.

*The process.* 1. DILUTE Native Honey *with five or six times its own quantity of water, let it stand to settle, afterwards run it through a flannel strainer, and directly commit it to distillation; by which means, if two thirds of the whole quantity be drawn off, it will only yield an indolent water, retaining something of the smell of* Honey, *or the flowers from whence it was collected, but nothing of a spirituous, or vinous nature; for it will neither inebriate, burn in the fire, nor run in veins, but form into drops, on the still-head.*

*Virtues of the subject.* 2. The subject of this process is the *mulsum* of the ancients, so frequently met with in their writings; and famous for its laxative, aperitive, and refrigerating virtues; and, indeed, it sometimes proves a successful remedy, when stronger and more elegant medicines have failed.

*Virtues of the production.* 3. The distill'd water of this hydromel, or *mulsum*, is recommended against obstructions and inflammations in the fine, capillary, or most delicate and tender vessels, and, particularly, in suffusions and inflammations of the eyes; being externally applied thereto, after it has been warm'd over the fire. And, indeed, for this purpose, 'tis a very effectual, tho' a mild and gentle remedy. On which account it has been held as a very great secret in *France*.

*The doctrine of the process.* 4. This process informs us, that even the most pure, perfect and best elaborated of vegetable juices, will not by distillation afford a vinous spirit. Honey is a subtile juice, brought to the greatest degree of perfection by the heat of the sun, and all the requisite stages of circulation; whence it at length comes to be lodged in proper cells, which are always found in the flower of the plant; whereof it therefore is the ultimate and most consummate production. It appears to be the very marrow of the flower, from whence it distils in transparent drops; as is plainly seen in the lily, the *Corona imperialis*, the aloes-plant, and other vegetables, whose flowers are of the larger kind. Hence many are of opinion, that it is the nutriment of the embryo in vegetables, which the bees suck out of their flowers, and lodge within their gorge; where being detain'd a while, and possibly farther concocted, it becomes of a thicker consistence. Yet we see even this perfect vegetable juice contains no inflammable, or vinous spirit, before it has felt the force of fermentation. And the same holds universally true of the juices of all manner of fruits, and even of grapes themselves, tho' ever so pulpy, ripe, and perfect.

CHEMI-

# CHEMICAL and PHYSICAL HISTORY OF FERMENTATION, VINOUS and ACETOUS.

1. FERMENTATION is a change produced in vegetable bodies, by means of an inteſtine motion excited therein; the effect whereof is this, that the part which firſt riſes from them in diſtillation, is either a thin, fat, acrid, hot, tranſparent, volatile, and inflammable fluid, that will mix with water; or elſe a thin, acid, pellucid, leſs volatile, uninflammable liquor, capable of extinguiſhing fire. *Fermentation, what.*

Authors have been at a deal of pains to deliver an adequate definition of fermentation; but with all their care, they differ widely from each other; and not one of them affords us an accurate and genuine deſcription of the thing. And, for my own part, I freely acknowledge, that the definition here laid down rather deſcribes the effect of fermentation, than declares

declares what it really is: but I could not define it otherwiſe, without running into conſiderable errors. In matters of natural philoſophy, 'tis not a rational definition that will inform us of their nature; but whatever is of that kind can only be clear'd up, and made intelligible by obſervation; that is, by the knowledge which ariſes from an accurate conſideration of things.

Numerous phænomena preſent themſelves in the buſineſs of fermentation; and whoever would faithfully deſcribe, or rightly define that operation, ought duly to weigh and conſider them all. The authors who have wrote upon fermentation attempt to give us the definition of it from thoſe phænomena which themſelves obſerved therein; but, not being careful to remark, and conſider them all, and diſtinguiſh between them, they aſſumed ſome particulars as eſſential and peculiar to it, which are common to other things as well as to that: and by this means, they were led into error. He who would give an exact deſcription of fermentation, muſt ſet down what is conſtantly to be obſerved in it, and not to be found in any thing elſe; otherwiſe that will be taken for an effect of fermentation, which properly never belong'd to, or was produced by it. Fermentation, in itſelf, is a thing utterly unknown to us; and we can only become acquainted with it from its effects; we, therefore, include in our definition the ultimate difference it produces; by which it is diſtinguiſh'd from every other operation in nature. We ſay then, that fermentation is a change produced in vegetable bodies, becauſe the effects of a true and genuine fermentation were never obſerved to be produced in animal or foſſil ſubſtances; and an inteſtine motion is ſaid to be its effective cauſe upon this ſcore, that fermentation is not, like ſome chemical operations, perform'd by triture or attrition. The liquor obtained by means of it is called thin, becauſe none appears to be thinner than the ſpirit of fermented vegetables; acrid, becauſe it acts almoſt like fire, when applied to the tongue, or other parts of the body; volatile, becauſe there appears to be no liquor that is raiſed with greater eaſe: but 'tis this liquor's being totally inflammable, and at the ſame time capable of mixing with water, that ultimately diſtinguiſhes fermentation from all other operations in nature: for neither putrefaction, digeſtion, efferveſcence, nor any thing of that kind, will ever afford a liquor at once poſſeſs'd of both thoſe qualities. Putrefaction indeed, as well as fermentation, is perform'd by means of an inteſtine motion; but the former will never produce either of the liquors above deſcribed as the effects of fermentation; that is, neither a vinous, nor an acetous liquor. We ſee then, that there are two different effects of fermentation, the production of an inflammable ſpirit, and an uninflammable acid; and whatever operation will afford neither of theſe liquors, is improperly called fermentation: which, therefore, can only take place in the vegetable kingdom; for all the art in the world, ſo far as hitherto appears, will never gain ſuch ſpirits from animals or foſſils; and conſequently, never excite an actual and real fermentation in them:

them: for fermentation is the single operation in nature, by which such spirits can be obtain'd.

2. Any vegetable liquor so fermented as to afford the inflammable spirit above-mention'd for the first thing in distillation, we call wine: but if the liquor be so fermented as first to afford the acid, uninflammable one, 'tis term'd vinegar; by which we mean every thin, acid, volatile, vegetable liquor, capable of extinguishing fire. So likewise, under the name of wine, we include beer or ale, mead or metheglin, cyder, perry, all sorts of artificial wines, and whatever liquors afford spirits possess'd of the properties before set down. The like is to be understood of vinegar, which is obtainable from all the same bodies that afford wine: so that we have either the wine, or vinegar, of all sorts of fruits, as of grapes, currants, mulberries, cherries, *&c.* all sorts of grain, as barley, wheat, oats, *&c.* all sorts of pulse, as beans, pease, tares, *&c.* all sorts of roots, as turneps, carrots, radishes, *&c.* and in short, of all sorts of vegetable substances, even grass itself. *Wine and vinegar, what and whence.*

3. All the bodies capable of being changed by fermentation, either into wine or vinegar, are said to be fermentable bodies; and because such a change can only be wrought, so far as we know at present, upon vegetables, these alone are accounted fermentable: tho' at the same time we do not say, that every vegetable substance is naturally capable of fermentation. Mustard-seed, onions, *&c.* afford a fetid liquor by distillation; which is rather the effect of putrefaction than fermentation in them. *Fermentable bodies what.*

4. Any matter, which being mixed with a fermentable body, increases its intestine motion, or excites, or forwards the fermentation, is call'd a ferment. And, according to the doctrine before deliver'd, nothing can properly be called so but what will produce either wine or vinegar. *Ferments what.*

5. The subjects of fermentation, or fermentable bodies, being separately consider'd, are very various, and almost innumerable: we shall, therefore, consider them in the several classes under which they are ranged by the different ways made use of to ferment them. In order to produce wine from grapes, a different method must be taken from that which we make use of to obtain it from barley. For, if grapes were first steep'd in water, then drain'd of their moisture, and afterwards thrown into heaps, or couches, as barley is, in order to be made into malt, they would rot, and afford nothing at all of a vinous nature. Hence there appears a necessity for considering vegetable, or fermentable bodies, according to the manner which ought to be pursued in their respective fermentations. And since several of them may commodiously be treated in the very same manner, 'twill be convenient to reduce as many as are capable of it to the same class; whence, by going over a few such classes, we shall readily understand how to ferment all sorts of fermentable *Several ways of fermenting vegetables, according to their classes; viz.*

bodies;

bodies; without being at the pains separately to consider every particular subject of the vegetable kingdom.

*The mealy seeds,* 6. The first class, according to this method, will consist of the mealy seeds; by which we mean all the grain, that, being fully ripe, and well dry'd, may be reduced, by grinding, to a light meal, or flower, that is neither clammy, nor unctuous. Of these seeds there are three kinds; *viz.* (1.) All manner of bread-corn, growing in ears, and having a grassy leaf; such as the several sorts of rye, barley, wheat, rice, millet, buck-wheat, and other seeds, which, on account of their likeness, are reckon'd among them; such as flax-seed, canary-seed, spelt, oats, the seeds of melons, pompions, cucumbers, *&c.* (2.) The several kinds of pulse; as beans, peas, tares, lentils, cicers, or the chich-pea, french-beans, heath-peas, lupins, cammoc-seed; with the mealy seeds of all other podded vegetables, which bear a papilionaceous flower. (3.) All the nuts, which are not over-stock'd with oil; such as the chest-nut, the hazel-nut, the wall-nut, the pistachio, the almond, the cocoa-nut, *&c.* with their subordinate species. The more unctuous kinds of nuts may likewise be ranged under this class, provided they are first dry'd, or otherwise freed from their too great proportion of oil, before you commit them to fermentation.

*Summer-fruits,* 7. Under the second class we range all the pulpy summer-fruits, which, when ripe, affect the tongue with the sense of acidity and sharpness; as pears, apples, medlars, services, apricots, peaches, plumbs, *&c.* various kinds of berries, as the goose-berry, the mulberry, the elder-berry, *&c.* cherries, grapes, currants, *&c.* melons, pompions, *&c.* Under this class also may be ranged all manner of bulbous, pulpy roots, growing in the ground; if they are but first depriv'd of their volatile, alkaline salt, which is apt to determine them to putrefaction; such are turneps, parsnips, carrots, onions, garlic, *&c.* for, notwithstanding their alkaline nature, these will afford a vinous spirit, after they have begun to sprout. To these we may also add lemmons, oranges, citrons, *&c.*

*Juicy parts of plants,* 8. The third class takes in all the juicy parts of plants, as the leaves, flowers, stalks, and roots; provided they are not too oily, or too alkaline; in which case vegetables will rather putrefy than ferment; and accordingly, some antiscorbutic plants, as scurvy-grass, brook-lime, mustard, *&c.* being fermented, and committed to distillation, yield a spirit, which proves rather alkaline, than acid or inflammable.

*Express'd vegetable juices.* 9. The fourth class contains the fresh expressed and native juices of all kinds of vegetables, especially of the subjects specified in the second and third class; to which may be added, all the native saline liquors, that distil from wounded plants; as the tears of the vine, the wall-nut, the beech-tree, *&c.* which presently fall to fermenting, if let stand in a warm place. By the way, *Helmont* tells us, in his treatise *de Lithiasi*, that he observed a birtch-tree to weep a very large quantity of liquor about the end of the month *February*, and the beginning of *March*; which being

being drank, prov'd of great service in case of the stone: and Mr. *Boyle*, coming to make the experiment, found, that if the liquor was used fresh, as it came from the tree, it had a very good effect in that distemper; but none at all after it was once grown stale: accordingly, *Helmont* himself cautions us, not to let this juice ferment before 'tis given for the purpose already mention'd, "lest (says he) from a cooling liquor, as "it is, it should become heating."

10. Under the fifth class come the most perfect of all vegetable juices, *viz.* those which are unctuous, condensed, and elaborated by nature herself; such as honey, manna; sugar, the pulp of *casia fistularis*, or the pudding-pipe-tree, with all other kinds of concreted juices capable of dissolving in water; or such as are neither balsams, gums, nor rosins. All these juices are, doubtless, to be esteem'd as vegetable productions: 'tis impossible we should question, whether honey is of a vegetable nature, or not, when we know it to be a thing which the bees gather from flowers, and which they neither take into their mouths, nor lay up in their stomachs, but commit to a particular cavity, or receptacle made on purpose to receive it; from whence they can again discharge it unalter'd. Thus also, we are well assured, that manna is not a vapor, or dew, let down from the upper regions; but a humor, that being made to sweat from the leaves of trees by the sun's heat, is gather'd early in the morning, whilst it lies condensed upon them. In like manner, sugar, and other similar juices, are to be esteem'd as vegetable bodies. *Unctuous and perfect juices of vegetables,*

11. The sixth and last class of fermentable bodies consists of the waters of those rivers, in which large quantities of vegetables have been thrown, and dissolved; as must be the case more particularly in the rivers upon which stand very large and populous cities; as the *Thames*, the *Seine*, *&c.* For, if these waters are taken up in warm weather or climates, and committed to proper vessels or casks, they will at length ferment. *Wandwoords* tells us, in his treatise of fermentation, that this was observed of some water taken up under the equinoctial line; which might proceed from the ferment, left in the containing casks by the vegetable liquors they held before. Some *English* men bound upon a voyage to the *East-Indies*, having fill'd several hogsheads with *Thames*-water to take along with them, observed an intestine motion in it when they came to the *Equator*; and found it afterwards turn'd into a kind of vinous liquor, capable of affording an inflammable spirit by distillation. But this, without dispute, proceeded from the flowers, leaves, roots, or other parts of vegetables, which continually fall, or are wash'd down into that river. But these particular waters are found in a state of putrefaction, before they put on a vinous nature; and their fermentation is observed to be promoted by any fermentable body thrown into them; or by being only kept in casks, which before contain'd any fermenting liquor: so that water appears not, properly and strictly, to ferment of itself, but by *and river-waters.*

accident only. This ſeems to be farther confirm'd by ſome repeated experiments made in *England*; whence it appears, that thoſe waters which have for long time run over vaſt tracts of land, are the moſt diſpoſed to ferment in the casks; ſince ſo long a courſe muſt needs give the greater opportunity for them to be mix'd and impregnated with vegetables and their juices.

*The requiſites to fermentation.* 12. In order to fit any of the fermentable bodies before-mention'd for fermentation, there are ſeveral particulars requiſite; as (1.) maturity. The juice of unripe berries, as of currants, or gooſe-berries, for inſtance, will ſcarce be brought to ferment at all; whilſt it is very difficult to hinder their juice, when fully ripe, from falling ſpontaneouſly into fermentation. Thus, the juice of unripe grapes, being incapable of fermenting, is a rough, acid liquor, call'd verjuice, that will for ſeveral years remain in the ſame unactive ſtate; but, after they are come to maturity, it can no ſooner be preſſed into the veſſel, than it becomes a fermentable, ſpirituous fluid. (2.) Another requiſite to prepare a body for fermentation is, that it ſhould contain only a moderate proportion of oil; for, if it either exceeds in the quantity, or be entirely deſtitute of oil, it will never be brought to ferment at all. Thus, almonds, fennel-ſeeds, *&c.* are always deprived of their oil before we attempt to ferment them: and unleſs this were done, they would alſo be apt to grow rancid. (3.) The bodies intended for fermentation muſt not be too acid or auſtere; as is plain from the acid juices of unripe fruits, which are greatly indiſpoſed to ferment: and ſo likewiſe the rough, auſtere juice of tormentil, for inſtance, is with great difficulty managed by fermentation. (4.) The laſt thing required to fit and prepare a body to undergo fermentation, is the property of diſſolving in water; for want of which, all acid bodies, and ſuch woods, roots, and herbs as are hard or dry, become unfit for this operation; for, unleſs the parts of theſe bodies are diſſolv'd, the requiſite inteſtine motion thereof will not enſue; but, without ſuch motion, fermentation cannot ſubſiſt. Hence honey itſelf can never be made to ferment, whilſt it retains its natural thick conſiſtence; but being diſſolv'd by heat, or let down with water, it immediately enters the ſtate of fermentation. On the other hand, ſo violently as the juice of grapes affects this ſtate; yet, if immediately after it is expreſſed, it be reduced, by boiling, to the conſiſtence of a jelly, 'twill lie quiet, and never ferment at all, unleſs it be again diluted, or let down with water.

13. According to the definition above laid down, a ferment is any matter, which, being mix'd with a fermentable body, expedites the fermentation. And, of ſuch ferments there are two kinds, the natural, or ſpontaneous; and thoſe produced by fermentation. Some indeed pretend, there can be no fermentation without a ferment; but then we ſhould be at a loſs to account for the firſt ferment that was ever employ'd.

ploy'd. On the contrary, it is very manifest, that fermentation may be spontaneous; for, we see, that the recent juices of some ripe plants cannot be pour'd out of one vessel into another, but they fall of themselves into a state of fermentation. The spontaneous or natural ferments then are (1.) All the fresh expressed juices of fully ripen'd plants, which easily run into fermentation. And (2.) honey, manna, sugar, *casia fistularis*, and the like thick, or inspissated vegetable juices, which cause a strong fermentation. (3.) The ferments produced by fermentation, are the fresh flowers, or yeast, of any fermenting vegetable juice, or liquor, as of wine, beer, *&c.* By flowers, or yeast, we understand that light frothy matter, which covers the surface of the fermenting liquor in the nature of a tender crust, and which, being added to any other fermentable juices, will excite a fermentation in them. (4.) The fresh *fæces*, or lees of any fermenting liquor, as of wine, ale, beer, *&c.* For, all fermentation divides the liquor, which is the subject of it, into three parts; *viz.* the flowers, or yeast, which possess the uppermost place; the operating, or fermenting fluid, which lies in the middle; and the gross, and seemingly exhausted matter, which, falling to the bottom of the vessel, is known by the name of lees, sediment, fæculence, or mother, that will, if raised again into the liquor out of which it was precipitated, cause it to work afresh. Thus, when a hogshead of wine has done fermenting, and is fined down, if the vessel be any way shook, or disturbed, it will grow turbid again, and ferment anew; as vintners very well know. For, such as were the flowers in the act of fermentation, such is the mother after the action is over. (5.) Acid paste, or baker's leaven, which is no more than any kind of meal brought into a close lump, by means of water, after the same manner as common bread is made; for, this being set in a warm place, during the space of four or five days, it will first swell, then turn very acid, and at length become a ferment. Whence we are furnish'd with an artificial way of preparing a ferment, upon occasion, when a natural one cannot be procured. And it is a custom with bakers to lay by a lump of their dough, to serve, as leaven, for the next bread they make. (6.) Those ferments, which reside in, or stick to the sides of the casks that have contained fermenting liquors. For, such casks will, of themselves, raise a fermentation in the liquors committed to them; and *Helmont* was of opinion, they might be capable of doing this for ever. Upon account of this inherent ferment it is, that old-season'd vessels *, or such

* 'Tis very remarkable, tho' a thing well known to brewers and vintners, that a new cask checks the fermentation of vinous liquors, and renders them weak and spiritless: for which reason, they never chuse to make use of such a cask before it is season'd, as they call it, by having first contain'd some spirituous, or fermented liquor, or other, which, being plentifully drank in by the wood, the original liquor comes to be deprived of a large proportion of its spirit, and more fermentable part; whence the remainder must needs taste flat and vapid.

as have long been employ'd by vintners, or brewers, bear so great a price among them. This is certain, that even must itself will not easily ferment in a new and pure vessel; but with the greatest facility, if put into one that has before contain'd fermenting juices: for the parts of the fermenting liquors with which such a vessel must have been impregnated, presently rouze and determine it to action. (7.) Besides the ferments already mention'd, there are some which appear to be heterogeneous, or ferments, improperly so called; as the white of an egg beat into a froth, which is used when the liquor to be fermented proves too dilute or thin to sustain the operation: for, in this case, the fermentable parts of the fluid easily extricate themselves, and so fly off, for want of something to detain and keep them in the body of the liquor; which, therefore, requires some viscid substance to be mix'd with it, in order to prevent this avolation of its subtile parts: and this cannot be more commodiously effected than by the white of eggs. Thus, were we to ferment the juice of roses, for instance, 'twou'd be requisite, first, to mix the white of an egg with it, because it is by much too thin and watery to ferment of itself. (8.) Of the like heterogeneous kind of ferments are all fixed and acid salts. Thus, if the liquor design'd for fermentation be too acid to work kindly; the addition of an alkaline salt, as that of vine-branches, or any saponaceous substance, will, by taking off from the acidity, fit it for, and so promote the operation; but, if the liquor be of itself too alkaline, then tartar, or the like, ought to be added to it, to promote the fermentation. But this does not happen because either the acid, or alkaline salt is an actual ferment, as some chemists have vehemently contended for the alkaline; but, because the salts employ'd respectively temper, and take down the predominant acid or alkali, which before hinder'd the fermentation of the liquor. And, if such salts should, in due quantities, be mix'd with any proper subject of fermentation, possessed of all the qualities above set down, as requisite to it, the operation would be entirely check'd and prevented; so that alkaline bodies may as well be said to hinder, as to promote fermentation. (9.) And lastly, of the same sort are certain austere, or rough-tasted substances; as all harsh and green fruit, pomegranate-bark, and flowers, the tamarisk-bark, crab-apples, unripe medlars, *&c.* which, when the liquor design'd for fermentation, is too much broken in its parts, or dissolv'd in its texture, bind it together again, by their astringent quality; so that, tho' it was before too thin and aqueous, it is now reduced to a proper consistence for fermentation. Thus, when must proves thin and watery, it will not ferment kindly, unless some austere, or astringent ingredient, as red rose-leaves, or the like, be added to it, to thicken and improve its consistence; and, at the same time, prevent the air it contains from making too easy an escape. But, when a liquor is too austere, or its roughness proves so great that it cannot ferment, the addition of

*Heterogeneous ferments.*

of a fixed alkali, in a proper quantity, will remove the obstruction, and leave it at liberty to work. So likewise, when the operation is prevented by too large a proportion of acid in the liquor, the method is to throw chalk, crabs eyes, bole-armeniac, or the like, into it; but, if it be too unctuous, or oily, as is the case in some *Spanish* wines, salt of tartar is made choice of: and thus, as circumstances alter, different bodies are employ'd to stop, or promote fermentation in liquors.

And this is all we have to say on the subject of ferments. As for those who pretend there are particular ones residing in the human body, it lies upon them to shew, that they really exist, and have the properties belonging to actual ferments; which, it is my opinion, they will not easily do.

## PROCESS XXXIX.

### *Exhibiting the manner of preparing the first class of* Fermentable Bodies, *viz.* Bread-Corn, Pulse *and* Nuts, *for* Fermentation.

1. *THE subjects of the first of those classes into which we distributed all fermentable bodies,* viz. *eared-corn, pulse and nuts, are prepared for fermentation in the following manner. (1.) They are put to steep, during the spring-season of the year, in warm rain-water, till they appear to be thoroughly drench'd and soak'd, or render'd soft and tumid; which will usually require the space of twenty-four hours, but more or less, according as the season proves cold or hot. (2.) The water being well drain'd off from them, they are, in some moderately warm place, thrown into beds or couches about a foot high; and in this state they must be left till they begin to conceive a heat, and to shoot or sprout; by which means their oil is broke fine, and render'd volatile. (3.) But their farther growth ought now to be immediately prevented, by throwing the whole couch abroad, thinning its ranks, and exposing it to the air, the wind, the sun, or fire, that it may be thoroughly dried. (4.) Lastly, the seed so prepared is to be broken, and reduced to a kind of coarse flower or meal, called by the name of ground-malt; which fits it to yield its virtues readily to water. And now tis ready to be brew'd into a spirituous liquor, which we scruple not to call by the name of wine.* *The process.*

2. Rain-water is here made choice of to macerate the grain, because it abounds more in active principles than water of any other kind, especially in the spring of the year; accordingly, river-water is not found *Directions relating to it.*

found ſo good to brew withal, nor the winter a time ſo convenient for it: the beſt malt-drink is always obſerv'd to be that which was made with rain-water, and in the ſpring-ſeaſon; for, ſuch water, at this ſeaſon, is enriched with the unctuous, and active exhalations of vegetables, which, during the preceding winter, were ſhut up, and not ſuffer'd to go off, and diffuſe themſelves into the atmoſphere. If the heaps or couches, into which the macerated grain is thrown, be made too large, or deep, the middle of them will be ſcorch'd and burnt up, before the outſides are warm; and, if they are made too ſmall, the ſubject will not ſprout kindly. For, in this caſe, the vegetable ſeeds being thoroughly ſaturated, and plump'd up with the water wherein they were ſet to ſteep; and afterwards, by means of a ſtrainer, ſieve, or otherwiſe, freed from all the ſuperfluous moiſture, and then thrown into heaps; the little bodies here keep each other warm by their mutual preſſure and contact, 'till at length they grow ſo hot, that the hand cannot, without pain, be thruſt into the couch. And now it is that they begin to ſprout, and ſhoot; but, as ſoon as ever the leaves appear to have left the roots 'tis time to put a ſtop to their growth. 'Tis the nature of all entire and perfect vegetable ſeeds, if they have once imbibed any moiſture, and are either thrown into couches, or lie otherwiſe cover'd, to grow warm and ſprout; that is, the *embryo* in them is moved, begins to expand itſelf, and ſhoot out its roots; and, if they remain in this ſtate for the ſpace of twelve hours, and be afterwards diſtill'd, they will afford a fetid, urinous ſpirit: and even the coldeſt plant that grows will do this. It is manifeſt from the proceſs, that the ſteeping the grain or ſeeds in water opens their bodies, and renders them ſoft and yielding; as alſo, that heat puts their parts into motion: which ſhews us the nature of vegetation, or the manner in which all vegetables grow. The farther growth of the grain in the couch ſhould be prevented, at the inſtant of vegetation, otherwiſe all the ſpirit of the vegetable ſeeds would be loſt, and the mealy part that was left behind be render'd incapable of diſſolving in water. The brewers in *Holland* have a particular engine for this purpoſe, by means of which they can ſuddenly ſtifle the vegetation, and ſtop all farther growth: but, oily ſeeds may be allow'd to germinate ſomething longer than others, tho' none of them ſhould be ſuffer'd to ſprout much: to prevent which, they ought inſtantly to be dry'd; for, when once they are thoroughly deprived of their moiſture, they will ceaſe to grow. And he is eſteem'd the beſt artiſt in this way, who can render his grain ſoft and ſweet, without ſuffering it to ſhoot long; which wou'd conſume the oily part of the ſeed, whereby its mealy and ſpirituous quality would be de-

deſtroy'd. 'Tis therefore, to be ſpeedily dry'd: * but, if fire be made uſe of for this purpoſe, it ſhou'd be gentle, or elſe it wou'd ſcorch, or burn the grain; in which caſe, the ſpirituous liquor prepar'd from it wou'd be of a higher colour indeed; but it wou'd have an empyreumatical taſte; that is, it wou'd retain a ſtrong taſte of the fire, or the ſcorch of the ſeed. To avoid this inconvenience, 'tis the cuſtom in *Holland*, to dry the ſeed they treat after this manner in the wind; which, tho' it performs that office more ſlowly than the fire, ſeems the more natural way. Barley prepared after the manner above deſcribed, is called malt; or, in the language of *Tacitus*, *de moribus Germanorum*, *frumentum corruptum*; but there is a great difference between corn and malt; and even between crude barley and the malt that is made of it. For, firſt, plain barley is not ſweet, but retains the natural taſte of its plant, and feels rough and clammy in the mouth; whereas, malt has a ſaccharine ſweetneſs, bites criſp, and breaks between the teeth into a ſoft and ſoluble meal. Again, crude barley diſſolves with difficulty in hot water, and at beſt, makes but a viſcid and glutinous ſolution with it; whilſt malt is ſo diſpoſed to unite with water, that it diſſolves, as it were, ſpontaneouſly therein; and, if the water be heated, communicates all its virtue, and its whole ſubſtance to it, excepting only a chaffy husk, or *caput mortuum*: nor can it be brought to form into a paſte with water, as all corn, and in particular barley, readily does. Laſtly, malt being apt to run into a violent fermentation in the ſummer-ſeaſon, 'tis a rule, not to brew with it alone, at that time, but to mix it with ground-barley, which never underwent the proceſs above deſcribed; in order to abate of its violent diſpoſition; otherwiſe the vinous ſpirit wou'd fly off, and be loſt in the fermentation: but, in the winter, it may ſafely be committed to that operation without any ſuch mixture. This proceſs is accommodated to all the vegetables ranged in our firſt claſs; *viz.* eared-corn, pulſe, and nuts: ſo that, if any one deſires to make a wine of cheſtnuts, walnuts, acorns, or the like, he need only thus ſteep them in water, till they juſt begin to ſhoot; then ſpeedily ſtop their farther growth, by drying them gently before the fire; and laſtly, grind them: for, being now committed to fermentation, a very grateful and pleaſant wine will, by this means, be obtain'd.

* Our malſters do not immediately remove their macerated and ſprouting grain from the wet-couch, as they call it, to the kiln, but gradually prepare it for the action of the fire, by throwing it abroad in ſhallow beds, and frequently turning, or ſpreading it thin over the whole ſurface of a large floor; where the air, having free acceſs to it, carries off its moiſture, and leaves it in a fit ſtate to be readily dry'd, or criſp'd up by the gradually increaſed fire of the kiln.

## PROCESS XL.

### *Exhibiting the manner of preparing, or* Brewing Vinous Liquors *from corn, pulſe, and nuts; by an example in* Malt.

*The proceſs.*

1. *FROM the vegetable ſeeds of the firſt claſs, prepared after the manner deſcribed in the laſt proceſs, there are two ways of obtaining wine, by means of fermentation; but never without it;* viz. *either by fermenting the meal of crude corn, or ground-malt, for inſtance, together with its husk, chaff or bran, according to the method formerly deliver'd, in the proceſs for drawing the waters of fermented plants; or elſe, after the following manner, which exhibits the art of brewing.* (1.) *Upon any quantity of ground-malt pour as much warm water as will bring it into a kind of thin pap, or* panada; *and let them ſtand together for the ſpace of twelve or ſixteen hours.* (2.) *When the infuſion is perfectly made, or the water fully ſaturated and impregnated with the flower of the malt; all the liquor muſt be ſuffer'd to run off from the grains or husks.* (3.) *The liquor thus drawn off is afterwards to be boiled up to a due conſiſtence; which the higher that is, the ſtronger, or more vinous will be the liquor after fermentation; and the fitter for keeping.* (4.) *The liquor thus boiled muſt, after it has been ſuffer'd to cool again, be put up, to ferment along with a due proportion of ale-yeaſt into casks, the apertures or bung-holes whereof are but lightly cover'd.* (5.) *And after the fermentation ceaſes, the liquor is to be kept cloſe ſtopped up in the ſame veſſel.*

*Directions with regard thereto.*

2. The water here firſt poured upon the malt, ought not to be ſcalding-hot; much leſs ſhou'd it be in a ſtate of boiling; for, then it wou'd ſcald the malt, or run into it hard cruſty, clods or lumps, as if it were burnt, and ſo prevent it from giving out its virtue. But, if the water be only moderately hot, it will imbibe, and diſſolve all the mealy part of the malt, and leave nothing but the dry and chaffy husks behind. After the liquor is fully fermented, and ſtopped down, we call it beer, ale, or not improperly, barley-wine; for, it will afford an inflammable ſpirit by diſtillation, having no manner of empyreuma, or tang of the fire, and not poſſibly to be diſtinguiſhed from the genuine ſpirit of wine. *Tacitus*, therefore, did not ſpeak improperly, when he ſaid of the *Germans*, that they made a wine of malt, or prepared corn. This kind of liquor, we find, was not unknown to the ancients. *Herodotus* in *Euterpe* ſpeaks of it under the name of οἶνος ἐκ κριθῶν, or barley-wine. And *Diodorus Siculus* tells us, that the *Greeks* made a certain liquor, call'd ζῦθος, that is, barley-drink or beer, which was in no reſpect inferior to wine.

3. In

3. In order to fit the ſubjects of our ſecond claſs for this proceſs, *viz.* pulpy ſummer-fruits, and the roots of bulbous plants, in caſe they prove crude or hard, they are to be firſt boiled in water, and afterwards bruiſed; which will diſpoſe them for fermentation: but, if ſuch ſubjects are juicy, they may be directly ground to a pulp, or have their juice preſſed from them; or, if they are very ſucculent indeed, there may be no occaſion to bruiſe them, only directly to commit them to the preſs, and ſqueeze out all their juice. But, if their fleſh or ſubſtance be ſtrong and tough, it may be proper to raſp, ſhave, or cut them into ſmall pieces; which will be of ſervice in ſome bulbous roots, and make them yield their juice with the greater eaſe, and in greater plenty. And, in this manner, onions, turneps, and the like, are to be treated. But, ſuch bulbous roots as thoſe laſt mention'd, as alſo muſtard-ſeed, and other alkaline ſeeds, ought to be made to ſprout before they come to be fermented; or elſe they will rather putrefy than fall into a genuine fermentation. This end may be eaſily obtain'd, by boiling them a little in water, and ſoon after drying them by heat; and, unleſs ſomething of this kind be done, ſuch vegetable ſubſtances are apt to afford, in diſtillation, a neutral ſpirit, of a nature between an acid and an alkali: but, if they are duly prepared for fermentation, they will all yield an inflammable ſpirit.

*How all other ſubjects are to be fitted for this proceſs; as thoſe of the ſecond claſs.*

4. The ſubjects of the third claſs, *viz.* the ſucculent parts of plants, need only, in order to their fermentation, be beat to a thick kind of pulp, whilſt they are freſh, and mixed with a proper proportion of rain-water, that is, juſt enough to dilute them; for, if much water be employ'd, the ſpirit will be the weaker for it.

*Thoſe of the third.*

5. The ſubjects of the fourth and fifth claſſes, *viz.* the freſh, native juices, and weeping liquors of vegetables, with the condenſed and unctuous juices of the ſame, are to be diluted, and let down with rain-water to a due conſiſtence; which is then commonly thought to be obtain'd, when the compound liquor will juſt keep a new-laid egg afloat; but, ſome vegetable juices may naturally be of this very denſity or conſiſtence; and, in that caſe, they will require no water at all: if any be thicker, or denſer, they ferment not ſo kindly; and, if thinner, or rarer, they afford but a weak ſpirit. Thus, in order to ferment ſugar, treacle, or any common ſyrup, we firſt let down the matter with water, to the conſiſtence above-mention'd; and then, if there be occaſion, put yeaſt to it, to quicken the fermentation, and make it proceed kindly.

*The fourth, and fifth.*

6. The fermentable bodies of the firſt claſs, *viz.* corn, pulſe and nuts, prepared after the manner above deſcribed, ſcarce require any ferment to ſet them in action, during the ſummer-ſeaſon; but in the winter, a greater, or leſſer quantity of one is to be uſed, according to the temperature of the air, or the reigning degree of cold. Thus, to forty pints of a fermentable liquor prepared from the bodies of this claſs,

*What is required to ferment the ſubjects of the firſt claſs.*

we

we may, at a medium, during the winter, add one pound of honey, sugar, manna, or yeast; or, in defect of these, half the quantity of bakers-leaven.

*What to ferment those of the second.* 7. So likewise, the subjects of the second class; *viz.* prepared fruits, seldom stand in need of any thing to make them ferment; for, they generally begin to work of their own accord: but, if the weather shou'd prove exceeding cold, or the operation proceed but languidly, it may not be amiss to quicken it, by adding a small proportion of a ferment, as a little yeast, the lees, or mother of wine; or, even a little new wine may serve the turn.

*Third,* 8. The subjects of the third class also, *viz.* the prepared succulent parts of plants, require very little ferment, or none at all, to make them work in the summer-season; and no large proportion in the winter: but, in case any at all be required, nothing will prove more serviceable than honey, or sugar.

*Fourth,* 9. The subjects of the fourth class; *viz.* the prepared recent juices, and spontaneous tears of vegetables, are so far from requiring any ferment, that it often proves very difficult to restrain or check the fermentation they fall naturally into; especially if the season be warm, and the juices rich: at most, if the weather shou'd prove cold, they need only be set in a warm place to make them work.

*And fifth.* 10. The subjects of the fifth class, *viz.* the prepared, or inspissated juices of vegetables, require no ferment at all in the summer, and, but a small proportion in the winter, to set them on working; less than an ounce of yeast to twenty pints of prepared liquor, will usually suffice for that purpose in the coldest season. But, in hot countries, or sultry seasons, these prepared juices, and especially sugar, are, of themselves, apt to fall into too violent a fermentation; which, therefore, ought to be abated by the contrary means.

*The general method of committing them all to fermentation.* 11. All the vegetable bodies of these several classes, design'd for fermentation, and prepar'd for it in the foregoing manner, ought, together with their ferments, to be committed to casks of oak, already season'd, or imbued with the same kind of fermented liquor, or some other, consisting of subtile and penetrating parts; then these casks, or vessels, having their bung-holes lightly cover'd with a thin, or single cloth, and, being set in a warm place, the liquor will ferment. The mouths of the vessels are thus slightly cover'd over, that the air may have a free passage in and out at them; for, they are here design'd to serve as vent-holes. And these vessels are order'd of wood; because fermentation is never observ'd to be so well carried on in those of glazed earth, or glass; though, on account of their transparency, 'tis sometimes perform'd in the latter, that the phenomena may the better be observed.

*Phenomena observed in fermenting liquors.* 12. The preparatory business of fermentation, hitherto described, has been carried on by art; but, nature must now perform the rest of the

the work; ſo that we are here only concerned to obſerve the phænomena which ariſe in the operation. When, therefore, any fermentable body is prepared after the manner above deliver'd, and, with its due proportion of a ferment, committed to a large, ſtrong glaſs-veſſel, ſtanding in a warm place, (1.) The whole body of the liquor ſoon begins to ſwell, heave, rarify, and ſend up little bubbles to the top of the veſſel, where they burſt with an audible noiſe, and form into froth: now, the liquor, which was before tranſparent, grows opake; and a violent uninterrupted inteſtine motion manifeſts itſelf therein. (2.) The parts of the fermenting fluid appear to be incredibly elaſtic, and the motion of them exceeding violent. Indeed, by means of this property of fermentation, very terrifying and ſurprizing actions may be perform'd. Thus, if a hundred pints of muſt were, on ſome warm day in autumn, to be confined cloſe in a veſſel of oak above an inch thick in the ſides, and made ever ſo tight and ſtrong by iron-hoops, yet could not this prevent the working of the liquor; but, in ſpite of ſo great a reſiſtance, it wou'd burſt the veſſel, with a report as loud as that of a cannon. And, therefore, the way to preſerve new wine in the ſtate of muſt, is to put it up in very ſtrong, but ſmall casks, firmly cloſed on all ſides; by which means it will be kept from fermenting: and then it goes by the name of ſtum, and is an excellent ferment. But, if it ſhould happen to fall into fermentation, the readieſt, and only way to ſtop it, is by the fume of ſulphur, or ſomething of the ſame nature. * (3.) A thick skin, or cruſty ſcurf forms itſelf on the ſurface, thro' which the elaſtic or fermenting matter is continually breaking. This cruſt appears to be the principal cauſe of fermentation; for, it keeps in, or prevents the ſpirituous part of the liquor from flying off: and, if it be frequently broken, it puts a check to the fermentation, and will often entirely ſtop it if wholly taken away. (4.) This skin, or cruſt, which we now call flowers or yeaſt, gradually conſumes, and precipitates to the bottom of the liquor; in which caſe, 'tis called by the name of *fæces*, or mother; and after this, the fluid above it immediately becomes tranſparent again, ceaſes to hiſs and bubble, has a very penetrating, pungent, ſpirituous, or vinous ſcent and taſte, with a mixture of acidity and ſweetneſs: and now the liquor, having undergone the operation of fermentation, is become wine.

The vapor ariſing from the liquor, during its fermentation, ought not to be approach'd too near, or breathed in too great a quantity, be- *A caution to be obſerved in fermentation.*

* Were it not for a knowledge of this property of burning ſulphur, the wine-merchants and vintners might frequently ſuſtain great damage from the burſting of their veſſels, when the liquor is upon the fret; or, by ſome alteration in the air, or other accident begins to ferment again; but, the ſmoke of a little common brimſtone, or a lighted match dip'd in it, and held under a cask of wine that is juſt ready to burſt its hoops, will calm its fury, and make it ſubſide as ſuddenly as a ſpoonful of oil, thrown into a large foaming copper of boiling ſugar, takes down its head, and prevents the miſchief it might otherwiſe occaſion.

R cauſe

cauſe it is highly poiſonous; and, if it proves not mortal, may, at leaſt, render the perſon apoplectic or paralytic. We have accounts, in the *French* and *German* tranſactions, of people who were immediately ſtruck dead, by receiving at the noſe the fumes that iſſued from large veſſels of wine in the ſtate of fermentation.

And now, if the liquor thus fermented be ſtopp'd down cloſe, it will begin to work, or feed upon, and digeſt its own lees, or mother, and at length conſume them; in which caſe we commonly ſay, the wine begins to ripen; and afterwards, this mother ſhoots to the ſides of the containing veſſel, and there appears in the form of an eſſential ſalt, which is then called tartar.

*How performable to beſt advantage.* 12. The ſpace of time required for finiſhing the fermentation differs with the ſubject-matter, the ſeaſon of the year, the nature of the place, and other circumſtances; but it is known to be perfectly perform'd by the ſeveral phænomena juſt now mention'd. As ſoon as ever the flowers fall to the bottom, the veſſel ſhou'd be bung'd down; otherwiſe the volatile parts wou'd fly off, and the fermented liquor become vappid and flat. In this ſtate it ought to ſtand for ſome weeks in a cool place; by which means it will grow ſtronger, and more liquid: for during this time, it imbibes and conſumes its own *fæces*, which abound in ſubtile ſpirituous parts, and grows ſoft, or loſes of its acidity, by throwing off its tartar. And the longer it is thus ſuffer'd to ſtand, the more ſtrength it gains; or, the more ſpirit it will yield in diſtillation. Thus, for inſtance, malt-liquors newly brew'd afford but a ſmall quantity of inflammable ſpirit; but, if ſuffer'd to remain for ſome weeks, in the veſſel, till they become fine and clean, they will yield a much greater proportion: tho', to avoid ſo great an apparatus of veſſels as would then be required, malt-liquors, brew'd in order to make ſpirits, are ſeldom kept, but immediately after fermentation committed to the ſtill. And hence we are furniſh'd with the reaſon why all ſtale, vinous liquors are ſtronger, and inebriate ſooner than ſuch as are new.

*Its phyſical effects.* 13. The phyſical properties of a vinous liquor, prepared in the manner above deſcribed, are thoſe which follow. (1.) It will have an inebriating quality, when received into the body: and nothing is properly poſſeſs'd of this quality but what has been firſt fermented. For, if a perſon ſhould eat ever ſuch a quantity of grapes, or drink ever ſo freely of muſt, he might indeed bring a looſeneſs upon himſelf by that means, but he would not be fuddled. So likewiſe, to take down large draughts of ſweet wort, or the tincture of malt, might throw one into a violent vomiting and flux; but never produce the ſymptoms of drunkenneſs. And whatever ſome pretend as to mandrake, hemloc, poppies, opium, and the like; the effects they have upon the human body are rather ſtupefying, than inebriating. But, drunkenneſs is different from ſtupefaction. An over-doſe of vinous liquors firſt makes a man briſk, lively and joyful, or diſpoſes him to ſing, dance, and be merry; at length, how-

however, his leggs will not ſupport him; and, if the fit be violent, he grows furious, raving or paralytic, and ſo he dies. But opium has not theſe effects: it brings on a profound ſleep; and he who has taken too much of it dies lethargic. (2.) It has the faculty of heating the body; which ſhews us the propriety of the *Roman* phraſe, *incaleſcere vino*, to grow warm with wine. Nothing appears to cool the body more than currants; yet the wine prepared from them is very heating. The like is to be underſtood of cherries, and all fermentable bodies, tho' ever ſo cold; for theſe will all afford a vinous liquor. (3.) It is inflammable, and will mix with water. (4.) It contains tartar, and affords it after the fermentation is over. This tartar is the eſſential ſalt of the vegetable made uſe of; and differs from the lees, or mother; being reſolvable, by diſtillation, into a water, a ſpirit, two kinds of oil, an alkaline ſalt and earth. All fermented vegetables afford it. Muſt yields a feculent ſalt, and no tartar; but if once it works ſo as to become pure wine, it will, in the ſpace of half a year, throw off a clean tartar; which, therefore, appears to be the effect of a perfect fermentation: and accordingly is never obtain'd without it. (5.) It retains neither the colour, taſte, nor ſmell of the ſpecific vegetable from which it was made. Thus we have ſeen, that roſemary affords a quite different water after it has been fermented, from what it did before. Thus fermented hydromel, malt-liquors, treacle, ſugar, *&c.* yield ſpirits, by diſtillation, that cannot be diſtinguiſh'd from one another. The grapes of ſome countries are as ſweet as honey, and ſo is their muſt before fermentation; yet the wine prepared from either may have little or no ſweetneſs; and ſometimes even gain a degree of acidity. It is not eaſy to believe, that *Rheniſh*-wine ſhou'd proceed from ſo ſweet a grape as it does. (6.) It acquires a ſomewhat acid and ſpirituous taſte and ſmell. The taſte of honey, or malt, *&c.* is ſweet, and their ſcent ſcarce perceivable before you commit them to fermentation; but, after having undergone that operation, they are leſs ſweet, but ſharper upon the tongue, and affect the noſe with a briſk, ſpirituous, or vinous odour. (7.) It contains the volatile ſalt and oil of the vegetable, attenuated, and reduced into one ſpirit; as may appear by the chemical analyſis of a fermented ſubject. (8.) It renders the oil of the vegetable more volatile than the water. When an unfermented vegetable is diſtill'd, the firſt thing that comes over is water, and the next the eſſential oil; but the contrary is obſerved after fermentation: for, by that operation, the oil is render'd more volatile than the water; and, therefore, riſes firſt in diſtillation; having been broke, and ground ſo fine by the preceding operation, as now to come over the helm, not in its own form, as before, but as the fineſt, and moſt volatile part of the fermented liquor, capable of uniting with water.

14. The things that promote or encourage fermentation are, (1.) Reſt; by means of which, the cruſt on the ſurface may remain unbroken: *By what means promoted.*

 for,

for, 'tis this crust that prevents the spirituous part from flying off. (2.) A free admission of the external air; so that it may come at the internal parts of the fermenting fluid. For, according to Mr. *Boyle*, if a fermenting liquor be put into his exhausted receiver, the operation immediately ceases. (3.) A moderate degree of warmth; for, too great heat, and too great cold, are the bane of fermentation. And (4.) A proper season of the year; that is, when the vegetables of the same species with that made use of are in their bloom; for, tis then their juices are most in motion: accordingly we find, when vines are in the blossom, the wine of former growths will again spontaneously run into fermentation. When these several conditions meet, fermentation is perform'd to the best advantage.

*How check'd, or moderated.* 15. The things which check or hinder fermentation are, (1.) Too large a proportion of acid salts; such as spirit, or oil of vitriol, oil of sulphur *per campanam*, spirit of salt, *&c.* Thus, when any liquor ferments too violently, a few drops of oil put into it, or the burning a little sulphur under, or near the vessel, will immediately check and restrain its fury. (2.) An over-proportion of fix'd alkalies; such are salt of tartar, pot-ashes, or saponaceous bodies. (3.) Terrestrial alkalies, as chalk, marl, crabs-eyes, *&c.* (4.) A close stopping up of the vessel. (5.) A great degree of cold. (6.) A violent degree of heat, or constant motion, so as to thicken the fermenting liquor, and render its parts hard to be separated. (7.) A total extraction of the air. And (8.) A violent compression of the air in the vessel; which Mr. *Boyle* has shewn will stop fermentation, as well as taking off the air by means of his pneumatic engine.

16. It remains now, that we consider the effect of vinous fermentation, as it regards the production or distillation of inflammable spirits.

## PROCESS XLI.

### *Exhibiting the method of distilling* BRANDY, *and inflammable spirits, gain'd by* FERMENTATION.

*The process.* 1. *FILL about two thirds of an alembic with any vinous liquor, prepared in the manner of the preceding process; lute the junctures, and with a moderate fire, sufficient to make the subject boil, draw off so much as to the taste runs free from the acid part, or will flame away, when thrown upon a naked fire: all which is to be kept by itself, in a close vessel, under the name of brandy, or inflammable spirit.*

*How performable to advantage, in juicy subjects.* 2. In order to make what we call real brandy, to distinguish it from other inflammable spirits, 'tis the general method to take the lees, and other

other feculent, grofs, or otherwife ufelefs parts of wine, or fuch parcels thereof as have been any way damaged or fpoiled, together with the leaft valuable parts of muft that can be procured, and throw them all together into one large wooden veffel to ferment, after the manner above fet down. And when this operation is finifh'd, and the liquor fitted, by time, for diftillation, 'tis committed to the alembic, and a proper degree of fire adminiftred, as in the preceding procefs.

*How fuch as are mealy.*

3. But when liquors are prepared from mealy feeds, or other mealy fubftances, for this procefs, there are fome particular cautions to be obferved, more than are neceffary when the fermented juice of grapes, honey, manna, fugar, or the like vegetable juices made into wine, come to be ufed in it. Thus, (1.) Care muft be taken, that the groffer matter of the liquor ftick not to the fides, or bottom of the ftill, where it is apt to run into a cake; which being burnt, or fcortch'd by the too near approach of the fire, the oil that was in it, mixing with the fpirit, communicates thereto an empyreumatical tafte and odour, which is very difagreeable. To prevent fuch an ill effect, 'tis proper to oil or greafe over the bottom and fides of the ftill with fome unctuous material, before the liquor is poured into it. Or elfe, the matter to be diftilled might be ftirr'd about with a ftick, till the fire below has made it hot; after which, the action of the fire alone will be fufficient to keep all the parts in motion, and prevent the groffer from falling down, or adhering to the ftill. Laftly, the fame good effect may be obtain'd, by firft heating the ftill, or boiling a little water in it; for, after it is thus made hot, or every where bedew'd with the vapor of the water, it will not eafily fuffer any part of the fermented liquor to grow to its fides fo as to be burnt. (2.) The fpirit muft, as much as poffible, be extricated and fet free from the more tenacious parts of the liquor; to which purpofe it will be convenient to mix and blend all the parts of it well together, before 'tis committed to diftillation. A large proportion of the fpirit is apt to lodge itfelf in the feculent part of fermented liquors; witnefs the lees of wine; which containing it in great plenty ought not, therefore, to be feparated from the wine that is defign'd to be good. So likewife 'tis very proper, before diftillation, thoroughly to mix the fediment, the flowers, and the body of the liquor together; or elfe to fet the whole, clofe ftopp'd up, in a cellar, or fome cool place, till it has imbibed its own *fæces*; whence it will afford a purer, a ftronger, or a more copious fpirit, capable of being long kept without any ill fcent. And therefore, if any wine, after long ftanding, is defign'd for diftillation, it ought not to be drawn off the lees, but fhou'd be fhook in the veffel before 'tis thrown into the ftill. (3.) The alembic fhould not be above two thirds full; that the flatulent, explofive matter of the liquor may not rife into the ftill-head; which it fometimes does, efpecially when urged by too large a fire, with fo much violence as to beat it off, tho' a great weight be laid on to keep it down; by which accident no fmall lofs has been fuftain'd. (4.) A piece of fine linen fhou'd

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be ſpread over the mouth of the alembic, which may be ſtretched and kept tight, by the head of the ſtill preſſing and reſting thereon at the juncture. By this means, any foulneſs, that might otherwiſe aſcend along with the ſpirit, will be kept back and prevented. This foulneſs is very apt to riſe when the liquor has not been well fermented; and is often the cauſe of that diſagreeable ſcent we ſometimes obſerve in malt-ſpirits.

When matters are thus prepared, and all theſe cautions have been duly obſerved, we may proceed to diſtil off our ſpirit with a gentle fire; which ought to be raiſed only ſo high, that one drop may juſt follow another: and this end may be obtain'd by every now and then applying the hand to the head or body of the alembic, to feel what condition it is in; and regulating the fire accordingly. This caution is more requiſite in diſtilling off ſpirits from the fermented liquors of mealy vegetables than in others; ſuch as thoſe of grapes, ſugar, *&c.* which may be ſuffer'd to run in a full ſtream. The fire ſhou'd be kept in this equable ſtate for the firſt hour; but may afterwards, or towards the end of the operation, be raiſed a little: for, at that time 'twill ſcarce cauſe any of the body of liquor to flow over into the worm; and the abſence of the more volatile part may not only allow, but require it. All vinous liquors afford their ſpirit, by diſtillation, as pure, limpid, and pale as water; but being uſually put up into casks of oak, by diſſolving the roſin out of the wood it gradually loſes of its paleneſs, and in time tinges itſelf of that yellowiſh, or amber-colour we commonly admire in brandy; tho' this is by no means natural to it, only an indication of its age or ripeneſs. After the ſpirit is clean drawn off, and the fire a little increaſed, there always comes over a rough aſtringent acid liquor, which is nauſeous upon the palate, and refrigerating to the body; and laſtly, when that has done running, a thick, fetid, empyreumatical oil, which gives a very diſagreeable odour to all the veſſels it touches. After the diſtillation is thus long continued, there remains a feculent pitchy matter, or black maſs at the bottom of the alembic, which, being calcined in the fire, affords a fixed, vegetable, alkaline ſalt, like that of *Tachenius*, and of the ſame virtues; being the very ſalt, and almoſt the ſame quantity the vegetable would have afforded, if it had never been fermented. And the like happens in all the bodies that ever I knew fermented, and thus examin'd; whence it appears, that fermentation is unable to deſtroy this ſalt.

*Nature, virtues and uſes of the production.*

4. All fermented vegetable fluids diſtill'd after this manner, and with theſe cautions, where they are neceſſary, afford different liquors at different times of the operation. The firſt that runs off is pungent, penetrating, heating, inflammable, exceeding volatile, or eaſier to be raiſed than oil or water; refreſhing, inebriating, ſtupefying, and balſamic, or endow'd with a preſervative, or embalming virtue. We call this ſpirit refreſhing, becauſe it proves highly ſo to perſons reduced to a languid ſtate, par-

particularly by a dropsy; and may in that case be conveniently employ'd: though at the same time we must own, that those who use it too freely commonly dye hydropical. 'Tis said to stupefy in this sense only, that if a man under any exquisite pain shou'd take largely of it, till he were intoxicated, he wou'd, for that time, be insensible of his torment. So likewise, when only applied externally, or rubbed upon a part that is in pain, it will give ease, or lessen the disagreeable sensation. And lastly, we say it is balsamic, because of the excellent faculty it has of preserving bodies from corruption, for a very long season. Thus, an *embryo* or *fœtus*, the parts of animals, whole insects, flowers, *&c.* may, without much alteration, or loss of colour, be kept in it for several years. 'Tis an excellent thing to keep anatomical preparations in; excepting only 'tis apt to fret off the *cuticula.* It is also of admirable use in chirurgery, where it happily cures gangrenes, mortifications, putrid ulcers, *&c.*

5. Thus we have given a short, and exact history of vinous fermentation, as it may be consider'd either physically, medicinally, or chemically; we have drawn out the materials, or subjects of it; exhibited the conditions requisite to fit them for it; the nature of ferments; the methods of working with them; and shewn the specific effect of this grand operation to be the production of an inflammable spirit. Whence we may learn the nature of must, wine, brandy, spirit of wine, and all manner of vinous liquors. According to our doctrine, every liquor fitted and disposed for fermentation is must; every duly fermented vegetable liquor, wine; and the spirit which it affords in distillation, spirit of wine, or brandy. Hence, likewise, it readily appears, that there is no action or operation naturally perform'd in the human body analogous to this of fermentation, since no inflammable spirit has ever hitherto been produced by a distillation of the parts of animals; but, on the contrary, all the distillations which have been perform'd upon such subjects, constantly afforded liquors of a quite different nature. It shou'd seem therefore, that, either the opinion of fermentation in animals ought to be given up; or else a new definition of that word must be advanced. *Recapitulation.*

## PROCESS XLII.

### *Exhibiting the manner of rectifying the* Inflammable Spirits *obtain'd by* FERMENTATION.

*The process.* 1. *THROW the ardent spirit of our last process into a still, (furnished with a worm and refrigeratory) whereof it ought not to fill above one half, or two thirds at the most; and with a fire which just causes the subject to boil gently, draw off two thirds of the original quantity: or continue the operation, till the acid part just begins to come over; and by this means there will be obtained the liquor called rectified spirit of wine: an acid water, of an unpleasant smell and taste, remaining behind in the still, with a few spirituous, and some unctuous parts, which were latent in the acid.*

*Its effects.* 2. We see, therefore, that unrectified, inflammable liquors consist of three different parts; a pure spirit, a phlegm or water, and an unctuous acid; the two latter whereof, in some degree, remain even in the purest spirits this process can afford; tho' in a considerably less quantity than before their rectification.

*Inconvenience.* 3. The spirits obtained from mealy substances, will, notwithstanding this purification, retain something of a disagreeable taste and odour, whereof they may be perfectly deprived by the process immediately following; so as to become undistinguishable from actual spirit of wine, or that prepared from the fermented juice of grapes; and, as some members of the *Royal Society* at *London* have shewn, altogether as excellent, in every respect, as the most perfect spirit of that kind.

*Nature of the production.* 4. Many chemical writers assert, that the spirits of this process will raise a conflict with all alkaline bodies; which is true, indeed, of those that have a volatile acid cleaving to them, from which they were not freed by distillation. This acid it is which causes the commotion upon the mixture of such spirits with alkalies: but the spirit itself, properly so called, and containing nothing of an acid, will never exercise the least hostility with alkalies. After the same manner, perfectly pure spirit of wine, prepared with alkalies, will make an effervescence when poured upon acids; tho' not as it is a spirit, but because some parts of the alkali, from which it was distilled, lodge themselves therein. All rectified, inflammable spirits, when perfectly pure, are of an indifferent nature, and neither acid nor alkaline.

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## PROCESS XLIII.

*Exhibiting the manner of preparing* ALCOHOL, per se, *or* perfectly pure Spirit of Wine, *from the* Production *of the preceding* PROCESS.

1. P*UT rectified spirit of wine into a tall, slender cucurbit, and to the mouth thereof fit a glass-head, made after the manner of an alembic; lute the junctures, and distil with a very gentle heat,* in balneo mariæ, *so as not to make the water of it boil, or else in a sand-furnace, as long as the ascending vapor continues to trickle in long veins, or rivulets, like oil, down the sides of the glass-head; but desist from the operation as soon as ever it begins to appear in the form of dewy drops: and thus you will have a purer spirit of wine; an unactive, unctuous and nauseous water remaining at the bottom, as in the process immediately preceding. This operation being several times repeated, with the liquor distilled over, will every time give us a spirit purer and purer, and leave a watery part behind. But when no water at all is left behind, the liquor, which then ascends insensibly, without any manifest signs of it upon the glass, either in the form of dew, or oily rivulets, is called* alcohol, *or perfectly pure spirit of wine.* *The process.*

2. The word *alcohol* is *Arabic*, and originally signifies a thing brought to its utmost perfection; 'tis used among chemists in two different senses; and stands for a dry, impalpable powder, as well as this perfect spirit of wine. To depurate or purify our inflammable spirits, as much as possible; that is, to separate them from their acid and aqueous parts, which obstinately adhere thereto, there are these two ways. The first is, by gently distilling them, without any addition, in very tall vessels, so that only the fine, volatile part thereof may come over; which is the business of our present process; and this in great measure deprives them of their water, but not of their acid; for that becoming more volatile by repeated distillations, always ascends readily along with the spirit. But the second method, which we reserve for the next process, is calculated to take away this acid part of inflammable spirits; and is called the method of depuration by alkalies. *Its nature.*

3. But after all our labour, the spirit will not be entirely free from acid and aqueous parts. I have myself distilled it seventeen times over; and still to the last it has left a nauseous liquor at the bottom of the vessel. The operation perform'd in this manner being so excessive tedious, it might save much time, and lessen the expence, if a proper alembic were here made use of; a very long, bent, conical tube of copper *Its inconveniencies, how to be remedied.*

ſupplying the place of the ſtill-head, and joining with the worm that paſſes through the refrigeratory.

*Ways of examining the purity of the production.* 4. There are three ways of examining the purity of our alcohol. (1.) If it be totally inflammable, without leaving the leaſt moiſture in the veſſel wherein 'twas burnt, 'tis generally accounted pure : tho' this is no infallible proof; becauſe a ſmall proportion of water might eaſily be made to exhale by the heat of the burning ſpirit. (2.) For the ſame reaſon, the trial of gun-powder cannot be depended upon : an ardent ſpirit may be ſo far inflammable as when lighted up, to burn dry, and at laſt, ſet fire to the gun-powder, whereon it was poured ; and yet contain ſome ſmall quantity of water, tho' not enough to keep the powder moiſt, and prevent its exploſion. (3.) But the moſt certain teſt of its purity is, if it will communicate no moiſture, nor in the leaſt diſſolve perfectly dry ſugar, ſalt, or fix'd alkali ; but leave them untouched, and no way altered. This criterion is infallible ; for were the leaſt drop of water to be harbour'd in the ſpirit, it would preſently be attracted by ſuch ſaline bodies ; as the magnet attracts iron ; provided they were thrown into it hot and dry. Thus, if a little ſpirit of wine be poured upon a few grains of hot and well-dried ſalt of tartar, placed in ſome pure veſſel ; the ſalt preſently imbibes and ſaturates itſelf with the aqueous parts thereof, relents, and runs, in form of a liquor. And hence we ſee the reaſon why, among the chemiſts, a dry, fine powder, which will not wet the fingers, is called *alcohol*, as well as perfectly pure ſpirit of wine.

*Its nature, qualities, virtues, and uſes.* 5. The product of our preſent proceſs is a very volatile, ſubtile, inebriating, heating, and totally inflammable liquor, endowed with a balſamic virtue, whereby it preſerves bodies from putrefaction ; 'tis alſo an admirable ſtyptic, ſtrongly coagulating all the juices of the human body, and ſuddenly conſolidating wounds, without leaving the appearance of a cicatrix. 'Tis capable of being mix'd with water, oil, and both acid and alkaline ſalts ; from all which it may again be ſeparated by a gentle heat : ſo that it appears to be the vegetable water of philoſophers, incapable of wetting the hands ; a property which belongs to no other fluid except, that mineral water, quick-ſilver. 'Tis very remarkable, that tho' it may be made to mix with all kinds of ſalt, yet no art can permanently unite it with oil of tartar, *per deliquium*. For tho' you ſhould ſtrongly ſhake it therewith for twenty-four hours together, till they appear to be perfectly blended ; yet as ſoon as ever the motion ceaſes, they fly aſunder, and continue ſeparate. Nay, I have faſtened a mixture of theſe two to the ſails of a wind-mill ; by the whirling motion whereof, they have for a long time been ſucceſſively ſhook together, without being at all able to unite them permanently. But this is more particularly true of that ſpirit which has been rectified from alkalies. And of all the liquors afforded by che-

chemistry, alcohol is the hardest to work any change upon. This spirit also is so exceeding volatile, that if a quantity of it were to be thrown up into the air of a hot room, scarce a drop thereof would fall upon the floor; but it would almost wholly remain floating aloft; as being the most subtile of all the known sulphureous liquors. 'Tis so inebriating, that if drank imprudently, tho' when it has not been rectified, or in a large quantity, it soon proves mortal, as we frequently find, by coagulating the blood, and inducing an apoplexy, whereof drunkenness is a species. Its balsamic virtue admirably fits for the preservation of animal, or vegetable bodies immersed therein; which it so embalms, as to make them retain their natural appearance for many ages: tho' it does not perform this office so well in some resinous plants; because by dissolving their unctuous parts, it in time deprives them of their colour, and itself thereby becomes thick and turbid. But birds, insects, *&c.* being first steeped for a few days therein, and afterwards suspended in a fresh parcel, may be preserved, with all their colours, in great perfection. Its styptic quality is so great, that being applied to the mouths of any bleeding vessels, it immediately stops the flux, by coagulating the blood; yet without causing an eschar, as vitriol and other potential cauteries always do. Upon which account we can safely apply it to the nervous, tendinous and most sensible parts of the body, where the common styptics are not to be trusted. When these tender organs are wounded, our alcohol has a wonderful effect; being applied with pledgets of lint. Hence it appears, that pure spirit of wine is not an aperitive, or discutient medicine, as it has been vulgarly supposed; for then it would never coagulate all the juices of the body, as we find it constantly does. Thus it instantly turns the *saliva*, the serum of the blood, the white of an egg, *&c.* to consistent bodies.

## PROCESS XLIV.

### *Exhibiting the manner of preparing* ALCOHOL *with Fix'd* Alkali.

1. POUR *highly rectified spirit of wine, or the alcohol of the last process, upon a third of its own quantity of pure, fix'd alkali, first made exceeding dry by the fire; digest them together in a tall, glass vessel, which is to be well shook, now and then, that all the parts of the alkali may come in contact with those of the spirit; then suffer the vessel to rest, and the alkali will fall to the bottom, having absorbed and drank in the acid and remaining aqueous, or oily part; and suffering the pure spirit to rise from it, and float on the top; which may therefore be readily separated* *The process.*

*parated by decantation, or a gentle inclination of the vessel, from the dissolved salt, wherewith it can never be brought to unite. What is thus separated, or else drawn off by gentle distillation, from the fix'd alkali, being again digested upon a fresh quantity thereof, in the very same manner; and the operation repeated till the fixed salt employ'd neither dissolves, nor in the least relents or grows soft, the liquor will then be alcohol, or perfectly pure spirit of wine prepared from fix'd alkali.*

*Particulars observable therein.* 2. There are three things in this process, which discover a particular consideration. (1.) 'Tis very remarkable, that the alcohol *per se* of the preceding process, tho' to appearance perfectly pure and simple, is really a compound body. (2.) The alkaline salt seems to dissolve, as it were, *per deliquium*, when the rectified spirit is poured upon it; and also undergoes a very considerable change from the latent acid of the liquor, tho' 'tis not destroyed thereby; but remains capable by exhalation, or calcination, of recovering its own form, and serving again for the same purpose. (3.) A disagreeable kind of oil appears to stick to the surface of the fix'd alkali; which oil has occasioned no small trouble to the chemists, who have not been able to guess from whence it should proceed; for they could never imagine that any oil should remain in the fixed salt, after it had suffered so great a violence of the fire; and pure spirit of wine, say they, gives not the least signs of any. But I have found, that a certain oil will constantly remain in the acid spirit of guaiacum-wood, tho' it does not at all appear at the first; but becomes visible after the spirit has been kept for some years, and tinges it of a different colour: whence I am led to suspect that the latent acid in spirit of wine contains an oil much after the same manner.

*Nature of the production.* 3. The general nature and virtues of alcohol, prepared from alkalies, are much the same with those of alcohol *per se*; except that the former is less perceptible upon the tongue than unrectified spirit of wine; being so light and volatile, as sooner to be dissipated by the heat of that part, than enter the pores thereof by its gravity, so as to excite the sensation of taste. This also, by participating of the addition wherewith it is prepared, retains something of an alkaline nature; so as to cause an effervescence upon mixing with acids. It may, however, be freed from this alkaline part, by gently distilling it over again from a due proportion of oil of vitriol; tho' in this case there is danger that the acid will predominate, so as to exercise an hostility with alkalies, when the spirit is poured upon them. Nor does there seem to be any way yet discovered, of perfectly freeing the two alcohols from their adhering acid and alkali.

*Nature of the operation.* 4. Hence we see 'tis much more difficult to purify fermented spirits, than is usually imagined; for how often soever they are distilled *per se*, they constantly carry over with them some proportion of an acid; and when

when rectified from alkalies, some proportion of them too. And I frankly acknowledge that I have no secret way of obtaining these alcohols in absolute purity; nor am I acquainted with *Helmont*'s method of resolving them into water and oil. 'Tis true, indeed, that if a common inflammable spirit be poured upon a fix'd salt, some quantity of water, and perhaps of oil too, will be separated therefrom; but I must profess I am unsatisfied whether this can be done in perfect alcohol, which seems to be almost as homogeneous a body as mercury; as it is the most simple indestructible and unchangeable of all vegetable productions.

*Introduction to the history of acetous fermentation.*

5. There remain two effects, or productions of fermentation, which we are still to consider; *viz.* vinegar and tartar. In order to understand the formation of these, we must take notice, that when a ripe vegetable juice, as that of grapes, for instance, is first expressed, it presently of itself begins to fall into fermentation; by means whereof, the saline matter contained therein is disposed to shoot into tartar, and fasten itself in a crust to the sides of the containing vessel; a parcel of grumous *fæces*, called the mother of wine, falling to the bottom: upon which the fermented liquor becomes transparent; and if now put up into a fresh vessel, deposites no more *fæces*; but still continues to shoot its shining, saline *spiculæ*, as well upwards as downwards, so as to line all the inside of the vessel therewith. This saline matter, or tartar, is really no more than the essential salt of the fermented juice of grapes; and is never afforded by must. It also contains no inconsiderable proportion of an earthy substance; so that it will not readily dissolve in water. The longer any wine remains in the hogshead, the more tartar it throws off, provided the vessel be kept full; and this whole quantity of wine being at length drawn off, and fresh substituted for it, the crust wherewith the vessel was lined, gradually increases in thickness, so as to render it necessary, or advantageous to break it away. But if, when this tartar is once form'd, the vessel be well and frequently shook, so as to mix the wine and the tartar together, they will begin to ferment afresh, the tartar will dissolve, and become more subtile, and the wine be converted into vinegar; upon which all the inflammable spirit of the wine is so changed, as to appear no more in its own form. The origin, or production of this vinegar we come first to consider.

## PROCESS XLV.

### *Exhibiting the origin and production of* Vinegar, *from liquors turn'd into* Wine *by* Fermentation.

*The process.*

1. *ANY manner of vinous liquor being mixed with its own fæces, flowers, or ferment, and its tartar, first reduced to powder, or else with the acid and austere stalks of the vegetable from whence the wine was obtain'd, which hold a large proportion of tartar, and the whole being kept frequently stirring in a vessel which has formerly held vinegar, or set in a warm place full of the steams of the same, will begin to ferment a-new, conceive heat, grow sour by degrees, and soon after turn into vinegar.*

*Its subjects.*

2. The remote subjects of acetous fermentation are the same with those of the vinous; but the immediate subjects of it are all kinds of vegetable juices, after they have once undergone that fermentation, which reduces them to wine: for 'tis absolutely impossible to make vinegar of must, the crude juice of grapes, or other ripe fruits, without the assistance of the vinous fermentation.

*The matters serving to promote it.*

3. The proper ferments for this operation, whereby vinegar is prepared, are (1.) The *fæces* of all acid wines. (2.) The lees of vinegar. (3.) Pulveriz'd tartar; especially that of *Rhenish* wine, or the cream or crystals thereof. (4.) Vinegar itself. (5.) A wooden vessel well drenched with vinegar; or one that has long been employed to contain it. (6.) Wine that has often been mixed with its own *fæces*. (7.) The twigs of vines, and the stalks of grapes, currants, cherries, or other vegetables, of an acid and austere taste. (8.) Baker's leaven, after it is turned acid. (9.) And, lastly, all manner of ferments compounded of those already mentioned.

*Nature of the production.*

4. Vinegar is no production of nature, but a creature of art; for verjuice, the juices of citrons, lemmons, and the like native acids, are improperly said to be natural vinegars; because, when distilled, they afford nothing but a vappid water; whereas, 'tis the property of a vinegar to yield an acid spirit by distillation.

*A different manner of conducting the process.*

5. In *France* they have a different method of making vinegar, from that described in our present process. They take two very large oaken vessels, the larger the better, open at the top, in each whereof they place a wooden grate, within a foot of the bottom. Upon these grates they first lay twigs, or the cuttings of vines; and afterwards the stalks of the branches, without the grapes themselves, or their stones, till the whole pile reaches within a foot of the brims of the vessels.

Then

Then they fill one of these vessels with wine, to the very top, and but half fill the other; then with liquor drawn out of the full vessel, fill up that which was only half full before; daily repeating the same operation, and pouring the liquor back from one vessel to the other; that each of them is full, and half full by turns. When this process has been continued for two or three days, a degree of heat will arise in the vessel which is then but half full, and increase for several days successively, without any appearance of the like in the vessel which happens to be full during those days; the liquor whereof will still remain cool: and as soon as the heat ceases in the vessel that is half full, the vinegar is prepared; which, in the summer, happens upon the fourteenth or fifteenth day from the beginning; but in the winter, the fermentation proceeds much slower; so that they are obliged to forward it by artificial warmth, or the use of stoves. But when the weather is exceeding hot, the liquor ought to be poured off from the full vessel into the other, twice a day; otherwise the liquor would be over-heated, and the fermentation prove too strong, whence the spirituous parts would fly away, and leave a vappid wine, instead of vinegar, behind. The full vessel is always to be left open at the top, but the mouth of the other must be closed with a cover of wood, in order the better to keep down and fix the spirit in the body of the liquor; for otherwise it might easily fly off in the heat of fermentation. The vessel that is only half full seems to grow hot rather than the other, because it contains a much greater quantity of vine-twigs and stalks than that, in proportion to the liquor, above which the pile rising to a considerable height, conceives heat the more, and so conveys it to the wine below.

6. This operation is constantly observed to proceed according to the following rules. (1.) The most generous, unctuous, strong, and full-bodied wines, afford the best and sharpest vinegar; but the weak, thin wines, the most poor and vappid. 'Tis therefore a great mistake to imagine that vinegar is nothing but corrupted wine, as there are many who persuade themselves. For the spirit of the wine does not fly off in the operation, but is fixed in the acid. (2.) The wine, in passing to the state of vinegar, deposites or throws off a fat oily substance to the sides and bottom of the containing vessel, as also to the twigs and stalks, infused therein; whereby they all appear to be cased over, as it were with soap. (3.) Unless this unctuous substance be quite cleared away, once a year, the wine will grow vappid, or turn to a liquor that is neither vinegar nor wine. But this is by no means to be done with hot water, but such as is cold and that with the greatest expedition, lest it should dissolve and extract the acid salts, or ferment, lodged in the pores of the vessels and ingredients; whereby they would become unfit for the purpose.

*According to what rules it constantly proceeds.*

purpoſe of making vinegar any longer; for inſtead thereof, they would then turn the wine into a kind of oleaginous liquor. (4.) The oftner the ſame ſtalks and twigs have been uſed in the making of vinegar, the better they are fitted for the work, and carry it on to the greater advantage; becauſe they every time imbibe a part of the vinegar, during the proceſs, and retain the ferment, lodged therein, for future operations. For which reaſon they ought not to be thrown away as uſeleſs every year, but only to be cleanſed of their unctuous matter; which then fits them for farther ſervice. And the ſame is to be underſtood of the veſſels; which ſuck in the ferment of the vinegar like a ſponge.

*How performable to advantage.* 7. The vinegar prepared, after the manner of our proceſs, from malt-liquors, or beer, provided they be good, differ in no reſpect from that of wine; tho' we commonly find it weaker: but this is not owing to the nature of the ſubject, but to its lowneſs of body and want of ſtrength. Strong beer, well brew'd, and duly fermented, may be made to afford as good vinegar as the richeſt wines; the inflammable ſpirit and tartar being alſo the ſame in both.

*The Things that forward it.* 8. The things which encourage and promote the acetous fermentation, are, (1.) Warmth. (2.) Admiſſion of the air. (3.) Frequent motion. (4.) The addition of the hot aromatics; ſuch as pepper, ginger, galangal, &c. which being added to the fermenting liquor, in the proportion of a dram to a pint, will make the vinegar exceeding ſtrong and pungent. But in *France* they never uſe any ſpice to their vinegar; becauſe, tho' it makes them ſtronger, it changes their nature.

*Thoſe that check it.* 9. This fermentation is check'd by all the ſame means that reſtrain the vinous kind, except concuſſive motion; which is here ſo far from being an impediment, that it greatly ſerves to promote and forward the working.

*Its phyſical effects.* 10. The effects of our acetous fermentation, when compleatly performed and ended, are, (1.) The production of vinegar; or an acid, volatile, penetrating, unctuous liquor, that makes an effervεſcence with alkalies, cools the human body, prevents the effects of drunkenneſs therein, greatly excites and refreſhes the brain, ſpirits, or nerves, and prevents all manner of corruption and putrefaction. 'Tis alſo attenuating, ſtimulating, ſudorific, diuretic, abſterſive, antipeſtilential, a powerful allayer of inflammations, and a preſent remedy in apoplectic and lethargic diſorders. (2.) A converſion of the inflammable, vinous ſpirits into ſuch as will extinguiſh fire. This property is very remarkable. We have formerly ſeen that all wines, by diſtillation, afford an inflammable, unctuous ſpirit; but if again fermented into vinegar, and treated in the ſame manner, they yield nothing of that kind. And yet the inflammable part of the wine does not exhale in the operation, but ſtill remains in the vinegar. For wine once deprived of its ardent ſpirit, can never be converted into vinegar: and we conſtantly

ſtantly find, that the more the wine abounds with ſpirits, the ſtronger and better is the vinegar made thereof. Whence we infer, that thoſe ſpirits are, by this ſecond fermentation, ſo fixed and united with the acid of the tartar, as quite to diſappear in their own form. That they are actually lodged in the vinegar is plain from hence, that by a certain art, 'tis poſſible to recover them, or produce ardent ſpirits therefrom. And this ſhews us the reaſon why the veſſel abovementioned, which, in the *French* manner of preparing vinegar, is only half full, is daily to be kept filling up out of the other that is quite full; *viz.* to extinguiſh or allay the too great heat in the liquor, by the cool wine of the latter; leſt the ſpirits we are ſpeaking of, ſhould thereby be made to evaporate, after the manner of diſtillation. (3.) A conſumption or diſappearance of the matter of the eſſential ſalt, or tartar, which is latent in crude vegetables, as we ſaw in our ſeventh proceſs, ſucceeded by an exceeding ſtrong vinegar, after the materials have once disburthened themſelves of a very great quantity of oil, which runs from them through the wooden grates, placed near the bottom of the large veſſels abovementioned; upon which the ſalts preſently unite with the aqueous and ſpirituous parts, and all together turn ſour by means of the new commotion: and this being once done, no more tartar is for ever after depoſited or thrown off by the vinegar. It might indeed ſeem probable, that when the oil was once ſeparated from the wine, it ſhould yield the greater quantity of tartar; the direct contrary whereof is true: and yet the tartar does not any way go off, but ſtill remains in the liquor, wherewith it is now more intimately united, and in a greater proportion, on account of the abſence of the oil. Whence it is not without reaſon that vinegar has by the antient chemiſts been called fluid, or volatile tartar. Indeed we may readily make vinegar from tartar; and conſtantly find that the more of it we employ in the preparation, the ſtronger our vinegar proves. In effect, vinegar is no more than the eſſential ſalt of wine, made more acid and volatile by a new fermentation, and intimately mixed with the ſpirituous, aqueous and oleaginous parts of the ſame. And if tartar be recovered from vinegar, it proves of a different ſpecies from that of wine. (4.) A diſpoſition of this vinegar to afford its phlegm for the firſt liquor in diſtillation; ſo that here the ſpirit appears to be fixed in the ſubject: as on the contrary it lies looſe in wine, and readily comes over firſt, when this is committed to the ſtill. In wine, the ſpirit is much more volatile than the aqueous part; but in vinegar 'tis heavier and more cloſely joined with the diſſolved tartar. *Vigani*, indeed, in his *Medulla Chemicæ*, aſſerts the direct contrary; and will needs have it, that an inflammable ſpirit riſes firſt in the diſtillation of vinegar. But for my own part, I could never find this to be the caſe. And 'tis probable, that in his experiment he made uſe, not

of perfect vinegar, but such as was in a middle state between that and wine; having not yet undergone its due degree of fermentation.

*Medicinal virtues and uses of the production.*

11. We have already enumerated the physical and medicinal properties of vinegar; the most exceptionable whereof are its being unctuous, penetrating, attenuating, or inciding, stimulating, preservative from corruption, antiphlogistic, sudorific, antipestilential, and curative of drunkeness. We call it unctuous, because in distillation it condenses not into drops like water, but trickles down the sides of the vessel in protuberant rivulets, like oil. 'Tis so penetrating as to pass the thickest filtre, without the least diminution of its virtues. Scarce any thing is more attenuating or inciding than vinegar, boiled up with honey, and diluted with a due proportion of water. This, I own, is contrary to the common opinion; for vinegar is generally thought to coagulate rather than attenuate the blood: but on account of its inciding virtue, 'tis highly useful in the small-pox, the plague, and burning-fevers, where the blood and juices are too thick and viscid; or where the humors tend to putrefaction. And when thus prepared, and taken down warm, it likewise proves an useful diaphoretic. Hence *Diascorides* and *Theophrastus* greatly recommend the use thereof in many acute cases; as particularly in the pleurisy, the *peripneumonia*, distempers from all vegetable or mineral poisons, and the bites of venomous creatures, and even that of the mad dog. Its stimulating virtue appears from hence, that it immediately raises such as are languid, lethargic, and apoplectic, more powerfully than the scent of the spirit of hartshorn, sal-ammoniac, *&c.* For which purpose we need only dip a linen rag therein, and apply it close to the mouth and nostrils; and by this means I have frequently recovered persons from fainting-fits, and preserved them from falling into the like. I have likewise had experience of the same remedy in lethargic cases, proceeding from taking of too large doses of opium. And it will also seldom fail in the syncope, or even in convulsive and hysteric fits. Its preservative or balsamic virtue is so great, that being used instead of salt, it will for several weeks preserve flesh sweet, in the heat of summer; tho' it be only wrapped up in a linen-cloth, first made wet therewith. And the same virtue it appears to exercise in the human body, when an inflammatory distemper is bringing a general corruption upon the juices. 'Tis so good an antiphlogistic, or so powerful a medicine in cases of inflammation, burning fevers, phlegmons, *&c.* that possibly we are not possessed of its equal. For this purpose 'twas used in all acute cases, and particularly being mixed with honey, in the *phthisis*, and other consumptions, or corruptions of the body. It also proves a wonderful safe sudorific, being of a refrigerating nature, and therefore highly proper to be given in inflammatory fevers, wherein 'tis so effectual, that when no other medicine can procure a sweat, this will rarely fail to do it. Vinegar also is justly esteemed for its antipestilential virtues, both as a preservative from the first attack of the plague, and the cure thereof, after

it

it has seized the person. *Sylvius* took two spoonfuls of it every morning, before he visited his patients, in a general plague-season, and all along remain'd perfectly free from every symptom of the distemper: but if he ever happen'd to miss taking his dose before he ventured abroad, he was presently seized with a pain in his head. And *Diemerbroeck* appears to have given it with great success in that violent plague of *Nimmeguen*, wherein as a physician, he was diligently employ'd. Lastly, it is somewhat strange, that a liquor, the basis whereof is wine, shou'd prevent, or remedy the effects of drunkeness; and this the more powerfully, the stronger or more spirituous the wine from whence it was prepared. If a person so drunk with wine, that he is, in a manner, quite stupefied, or render'd apoplectic or lethargic, takes but a spoonful or two of vinegar; he will thereby be immediately rouzed, and brought to himself for a time. And it is very remarkable, that those wines which afford the greatest quantity of vinegar, are less apt to inebriate than others. Thus *Rhenish*, which yields a copious vinegar, is much less apt to disorder the head than *French* wine; tho', by distillation, the former affords more inflammable spirit than the latter.

## PROCESS XLVI.

### *Exhibiting the method of resolving* VINEGAR *into a* Water, *an* acid Spirit, *an* Extract, *an* Oil, *and a* fix'd alkaline Salt.

1. POUR *a quantity of vinegar into a glass cucurbit fitted with a proper head, and distil off a fourth part thereof, with a gentle heat; this will prove to be a light volatile phlegm, or water, somewhat acid upon the tongue, and capable of extinguishing fire; and may, by repeated distillations, be almost totally converted into water; tho' it will still retain a few acid particles; whereof it may be entirely deprived, by the addition of a little chalk, which absorbing them all, will leave the water perfectly pure.* (2.) *If, after one quarter of the vinegar is thus run off, you increase the fire a little, and continue it at the same height, till two thirds of the original quantity is, in all, come over; this second running will be a spirit, somewhat like the former water, but much more acid and ponderous than that: and it will come over in a greater quantity, if the vinegar be not too new, but has been kept for some time.* (3.) *Urge the remainder with a stronger fire, and a still more acid, heavy, penetrating, and fix'd liquor will rise, capable of extinguishing fire: and this will continue to come over till only a twentieth part of the original quantity of the vinegar remains in the cucurbit.* (4.) *What now stays behind, at the bottom, appears in the form of a thin syrup, is of a very acid, and fat oleaginous nature, and may not improperly be called the rob, or sapa of vinegar; or if the operation be some-* *The process.*

*what longer continued, till the remainder comes to the consistence of honey, the extract thereof.* (5.) *The fire being now augmented as much as the glasses will bear, there will come over first a very strong acid, and afterwards a copious, thick, black, fetid, empyreumatical oil, like that of tartar.* (6.) *And lastly, what now remains behind is an acid, feculent matter, which, being calcin'd to white ashes in an open fire, will afford a violently strong fix'd alkali.*

*The cautions it requires.* 2. This process proves very tedious, if thus carried on in glass vessels, when, if we go to hasten it, we may chance to break them; 'twou'd be very convenient, for the sake of dispatch, or when a large quantity is to be distill'd, if it were perform'd in a common alembic; but then the head must be of glass: for, the strong acid that ascends in distillation, wou'd presently corrode one of copper, and mixing itself therewith, turn of a green colour. And indeed, notwithstanding the glass-head, the liquor barely by washing the sides, or upper part of the alembic, or body of the still, will carry off particles enough to give it a metalline taste.

*The doctrine it affords.* 3. It appears from our present process, that the acetous fermentation does not separate, or set free an inflammable spirit from its subject, so as to let it rise in distillation, as we see in the vinous kind of fermentation; but keeps it mix'd, and strictly united with the acid salts of the tartar, so that it now no longer appears distinct, or in its own proper form. But 'tis very observable, that if vinegar be boil'd upon lead, and afterwards distill'd from it in a tall cucurbit, the metal, which is greatly dispos'd to drink in vinegar, will thereby be dissolv'd into a sugar, or vitriol of lead, which in the operation affords first a water, or phlegm, and afterwards a liquor, and red kind of oil, totally inflammable. Some there are, who pretend that this oil is the sulphur of the lead; but in reality, it proceeds from the vinegar: for, the *Saccharum Saturni* is only the pure metalline part of the lead, associated with the acid of the vinegar into that particular glebe, according to the nature of such bodies. By distillation the vinegar is freed from its aqueous parts, upon which the lead strongly attracts the remaining acid, and strictly unites it to itself; so as readily to let go the oil that was latent in the liquor left behind in the cucurbit. This same oil, which one wou'd not expect to be so copiously contain'd in vinegar, is in wine so broke and attenuated, as presently to rise first in the form of an inflammable spirit by distillation, capable of mixing with water. But in vinegar, the tartareous matter being dissolved in this subtile oil, so fixes it, as to make it entirely disappear, till forcibly extracted therefrom by art; as in the distillation of *Saccharum Saturni.* Vinegar, therefore, is a farther production of art than wine; and appears to be the intimate combination, and strict union of all the active principles that are lodg'd in the subject from which it is prepared; and consequently, its medicinal virtues are greater than those of wine; as being, in reality, no other than an acid, volatile, oily salt.

4. The

4. The virtues of all the acid liquors diſtill'd over in this proceſs, are much the ſame with thoſe of the vinegar itſelf, being only of a more penetrating, and volatile nature; becauſe they are, by the operation, deprived of their earthy part. They otherwiſe differ only with regard to their degrees of acidity, wherein they conſtantly obſerve this rule, which is common to all acids, that the greater violence of fire they require to raiſe them, the ſtronger they prove; and this holds likewiſe in the diſtillation of woods. Theſe ſeveral productions are all capable of mixing one with another; and none of them contain any portion of an inflammable ſpirit. The extract, indeed, will burn in the fire; but this it does upon account of its oily, not its ſpirituous nature; being, in effect, a ſtrong ſoap, conſiſting of ſharp acid particles: and, upon calcination, it affords a very corroſive alkaline ſalt. Nor can ſtronger alkalies be poſſibly obtain'd, than what are afforded by vinegar. This extract is accounted an admirable medicine in the plague, and all peſtilential diſorders, and ſuch caſes as proceed from an alkaline putrefaction in the body. 'Tis alſo good in inflammations, a proper medicine to force a ſweat in burning fevers, and in ſhort, one of the beſt ſaponaceous bodies we have in acute diſeaſes, upon account of its acidity; but, being of an unpleaſant taſte, it ought, when taken, to be mix'd up with ſyrup, ſugar, or the like. The ſpirit of vinegar likewiſe, which comes over ſecond in our preſent proceſs, is an excellent medicine, when taken warm, ſo as to promote ſweat, in all caſes of poiſons, whether external or internal; and particularly good againſt the bites of venomous animals, as that of the mad dog, &c. And if any of the corroſive, deleterious poiſons, ſuch as *euphorbium*, white hellebore, &c. be boiled therein, they loſe of their force, and become harmleſs to the body.

*Virtues and uſes of the productions.*

## PROCESS XLVII.

### *Exhibiting the manner of rectifying* Distill'd Vinegar, per ſe, *from the Spirit of the preceding* Process.

1. *PUT the ſpirit of vinegar, or the ſecond and third running of the laſt proceſs, into a moderately tall cucurbit, fitted with a proper head, and diſtil, with a gentle fire, till one half of the original quantity be come over; all which will prove to be a weak and dilute acid, like the firſt running of the preceding proceſs; and leave behind in the cucurbit an exceeding ſharp and ponderous acid, which we call the rectified ſpirit of vinegar, and is always the ſtronger, and more pungent, the longer the operation is thus moderately continued.*

*The proceſs.*

2. Hence

*Its nature.* 2. Hence it appears, that the rectification of acetous liquors is the very reverse of that of the vinous. All wines or inflammable liquors totally lose their spirit by boiling; but vinegar becomes stronger by the same means, as being only deprived of its phlegm in the operation; for, the acid salt of the vinegar is too heavy to rise with a moderate degree of heat. We must own indeed, that if fish, flesh, bones, *&c.* be boil'd together with the vinegar, it thereby loses of its strength; but this proceeds from the gelly of the ingredients: for growing soft, they afford a mucilaginous or unctuous matter, that blunts, or sheathes the points of the acid salts in the liquor; and so render it less pungent upon the tongue. But vinegar, of itself, always increases its acidity by coction, tho' continued almost to dryness; but, after this, it begins to lose of its acid nature, and turn to an alkali.

3. Tho' all that comes over from the vinegar, in the preceding process, shou'd be rectified, or treated in the manner of the present process, not the least quantity of an inflammable spirit wou'd thereby be obtain'd: but the oftener the operation is repeated with the acid spirit, the stronger, and more acid it will grow.

*Use of the production.* 4. The rectified spirit of vinegar is of use in all the solutions of metals; where such a strong acid is required.

## PROCESS XLVIII.

### *Exhibiting the method of rectifying* DISTILL'D VINEGAR *from* METALS, *or* VERDIGREASE.

*The process.* 1. UPON *a proper quantity of common verdigrease pour four times its weight of the strongest, rectified spirit of vinegar, and digest them together, for the space of four and twenty hours, with a degree of heat little lower than that of ebullition; the vessel being, during that time, kept frequently moving; by which means the spirit of vinegar will acquire an exceeding pleasant green colour.* (2.) *This liquor being decanted clear off from the* fæces *of the verdigrease, let fresh spirit of vinegar be poured thereon, and the digestion be repeated, till the vinegar no longer colours itself, or gains any green tincture from the remaining metalline matter. The several liquors being now all mix'd together, pass under the name of the acid tincture of copper.* (3.) *This tincture having been filtred thro' cap-paper, is afterwards to be thrown into a cucurbit, fitted with a proper head, and distill'd over with a gentle heat, till the surface of the remaining liquor begins to form itself into a pellicule. But all the liquor that rises by this means will be chiefly aqueous, and prove flat, nauseous, and something acid upon the tongue.* (4.) *What now remains behind being placed in a cool cellar, will, in a day's time, shoot into fine transparent crystals, of a beautiful green, not unlike the emerald, to the sides of the containing vessel:*

*vessel; which crystals go by the name of distill'd verdigrease; and that part of the liquor which remains unchanged after the formation of these green crystals, being again exhaled to a pellicule, will now shoot after the same manner; and if the operation be often enough repeated, no liquor will be left untransmuted into the like. (5.) These crystals being thrown dry into a pure cucurbit, or glass retort, and distill'd with degrees of fire, up to the highest that can be given in sand, or till the remaining matter be perfectly dry; there will come over an exceeding ponderous, fat, and violently strong, penetrating liquor, containing a more copious acid, with the least proportion of phlegm, than can by any other art be obtain'd from vinegar; whereof it is the spirit rectified from verdigrease or copper. (6.) What is left behind at the bottom of the cucurbit or retort, appears to be no more than a dry powder; which, by fusion, will return to perfect copper.*

2. Verdigrease is here made choice of, as being the strongest metalline attractive, or magnet of the acid of vinegar we know; and readily turning with it into a metalline glebe, at the same time that it does not in the least destroy, impair, or change its nature; but leaves it perfectly unalter'd, and ready to be drawn away from it again by distillation. Other metals indeed, as well as copper, wou'd do the like, but with more trouble and difficulty; whilst the copper in the verdigrease is already so corroded, attenuated, and open'd by the acid of the grape-skins, wherein it had long lain buried, as to be admirably well fitted for our purpose. Hence we learn, that metals may absorb, or attract some certain acids, and barely lodge them in their pores, so loosely that a moderate degree of heat will serve to set them free, and make them appear in their pristine form. *Nature of the addition.*

3. The acid tincture of copper is a remedy of great use in all kinds of ulcers, where gentle corrosives and desiccatives are necessary. And four or five drops of it, in any proper vehicle, are an excellent and immediate vomit, highly proper in case of poisons taken down into the stomach, where a sudden discharge by the mouth is absolutely required, in order to the cure. *Virtues and uses of the productions.*

4. The distill'd verdigrease of our process makes an excellent pigment, that is highly prized by painters; tho' it is attended with one great inconvenience: for as the acid of it flies off, and cannot long be detain'd therein, it in time turns of a brownish colour.

5. Our acid spirit, rectified from the verdigrease, is a perfect vegetable acid salt, tho' mix'd with some particles of copper; which does not absorb or attract the aqueous part of the vinegar, but only the acid salt thereof: whence we have a clear instance, that salts dissolved in aqueous liquors may be separated from them by certain bodies which leave the water behind, but retain the salts without working any change upon them, in such a manner, that they may be thence easily recover'd again by heat. This liquor has greatly embroil'd the art of chemistry. It

was

was described by *Basil Valentine*, above two hundred years ago, under the name of *Esurine Vinegar*; and he wou'd needs have it to be the alkahest of *Paracelsus* and *Helmont*. In this opinion he was followed by great numbers, particularly by *Zwelfer*; but he is thoroughly confuted by *Tachenius* in his *Hippocrates chemicus*; who repeats it over and over again, that *Zwelfer*'s alkahest is nothing but vinegar. What seems principally to have led them into this error, was no more than their finding that such a spirit poured upon chalk, the *lapides cancrorum*, or crabs-eyes, *&c.* and distill'd, appear'd to be wholly converted into phlegm. And having thus imagin'd, that this acid was really transmuted into mere elementary water; they hastily concluded, that it was really turn'd into the liquor, or water alkahest. But this was plainly no proper transmutation at all; only a bare separation of the water from the acid part imbibed by the terrestrial alkalies. This rectified vinegar is greatly commended, as an excellent medicine, in case of a want of appetite proceeding from a putrefactive cause; provided it be used only as an ingredient in the preparation of *elixir proprietatis*.

## PROCESS XLIX.

### *Exhibiting the origin and production of* TARTAR, *from fermented, vinous liquors; by an example in* Rhenish-*wine.*

*The process.* 1. *THE must of* Rhenish-*wine having been once thoroughly fermented, perfectly changed into wine, and set in a quiet place, lets fall its* fæces *to the bottom of the containing vessel; whilst a clear and pure fluid remains floating above them.* (2.) *If this transparent purified liquor be drawn off from its lees, into another clean vessel, and suffer'd to rest in the same manner, a parcel of shining, saline, pellucid matter, or* spiculæ, *will by degrees form themselves all around upon the inside thereof; so as to compose an entire crust or case, which includes, preserves, and keeps in the spirit of the wine, much better than any wooden vessel. This saline matter, thus form'd and concreted, is called tartar: and now, the wine loses of its sharpness or acidity, and gradually becomes more mild, generous and rich.* (3.) *If the wine be again drawn out of its present vessel, and other new wine of the like kind be poured into the same, this will throw off its tartar sooner, and in a larger quantity; so that by repeating the operation, a case of tartar may be gain'd of a very considerable thickness; so as to fill up a large part of the vessel made use of; or even to serve for a vessel itself.*

*Nature of the production.* 2. Tartar, therefore, is nothing but the pure essential salt of the wine, obtain'd much after the manner of our seventh process; and by no means the feculent part thereof, which always falls to the bottom, and never,

never, like tartar, appears in ſhining cryſtals adhering to the ſides of the veſſel. 'Tis of an acid taſte, and conſtantly appears of the ſame colour with the wine which affords it. Thus, that of *Rheniſh* is white: and that of claret red. But no wine will afford it, unleſs it be perfectly pure and fine. 'Tis very difficult to diſſolve in wine, and requires the heat of ebullition, and twenty times its own quantity of water, before it will perfectly unite therewith; which are uncommon properties, conſidering it was at firſt latent, or imperceptibly diſſolved in the wine, which wou'd then readily mix with water. Hence it is, that wine contain'd in a hogſhead well-lined with tartar, never penetrates through it, but keeps freſh, good and ſpirituous, for ſeveral years ſucceſſively.

3. The origin of the word *tartar*, ſo laboriouſly treated of by *Paracelſus*, comes at length to this. We find it deliver'd by *Moſes*, that *the earth was curſed*, after the fall of *Adam* and *Eve*; but more particularly, the vegetable kingdom thereof. That is, ſays *Paracelſus*, all manner of vegetable ſubjects had then a certain force given them, far ſuperior to, or unconquerable by that of animal bodies; whence it became impoſſible for us to digeſt and aſſimilate ſome one part of them into our own nature. And obſerving, that there was a certain ſtone contain'd in, or afforded by all kinds of wine, or fermented vegetable juices, not eaſily diſſolvable in any common liquor, he wou'd needs have this ſtony matter to be the *curſe*; and accordingly term'd it *Tartarus* or *Gehenna*; at the ſame time aſſerting it to be the immediate cauſe of the gout, ſtone, all obſtructions in the *viſcera*, and other diſorders. And the ſame opinion was likewiſe entertain'd by *Baſil Valentine*, and many other chemiſts beſides. *Origin of the name.*

4. The medicinal virtues of crude tartar are very conſiderable, as being preferable to the cream, or cryſtals thereof; on account of the virtue it has to cleanſe the *primæ viæ*, and cure the diſeaſes to which they are ſubject. But, of itſelf, without ſome farther preparation or aſſiſtance, it can ſcarce enter the ſecond paſſages, or lacteals, by reaſon of its groſſneſs, difficulty of ſolution, and the want of a ſufficient heat, and quantity of liquor in thoſe parts, to break its texture, and run it into a fluid. Tho' we muſt acknowledge, it may be perfectly diſſolved, if it happens to meet with any ſtrong alkali; and therewith compoſe a penetrating ſoap, which may eaſily enter the mouths of the lacteals, cleanſe their paſſages, and break away any obſtruction that may chance to be form'd therein. Tho' when it is thus mix'd, ſuppoſe with the bile, or other juice, it no longer acts as tartar, but as a neutral ſalt, or ſaponaceous body. And tho' by this means, it may be render'd an exceeding penetrating, and ſubtile medicine; yet when barely diſſolv'd in water, it proves ſo groſs, as not to paſs a flannel-ſtrainer. In this ſtate, however, it admirably ſerves to disburthen the inteſtines of their load, without diſturbing any other part of the body; for which reaſon it ought to be highly valued: and in this reſpect it does not fall *Virtues and uſes of the production.*

ſhort of tamarinds; theſe two being the principal medicines that work after this peculiar, gentle manner. It likewiſe cures all diſtempers ariſing from putrefaction, a lentor and inactivity in the inteſtinal tube. To anſwer theſe ends, it is to be given in the quantity of ſix drams, or an ounce, in broth, water-grewel, or the like. This crude tartar being, as we have already obſerved, the native ſalt of wine well-fined, has no impurities mix'd along with it; for which reaſon it is, that its medicinal virtues exceed thoſe of cream, or cryſtals of tartar; for theſe are no more than crude tartar boil'd and diſſolv'd in water, and ſuffer'd to ſhoot afreſh; by which operation, as the tartar is not purified, ſo it loſes of its efficacy; the ſubtile ſpirit thereof being made to evaporate by the heat. *Angelus Sala*, an *Italian* phyſician, who, for ſome time, practiſed at the *Hague*, and of whom Mr. *Boyle* very juſtly ſays, that he was a candid chemiſt; has wrote an entire treatiſe upon tartar, entituled *Tartarologia*; in which he frankly diſcovers all his ſecrets upon that head, to the great ſatisfaction and advantage of phyſicians. In this book he tells us, he found it an excellent remedy in the colic, hyſteric diſorders, and ſtubborn obſtructions of the inteſtines; and particularly in ſuch caſes of the gout, and other diſorders as proceed from free living, or the uſe of rich wines and a high diet. And this he ingenuouſly acknowledges to have been his grand *arcanum* in theſe caſes; being given in the quantity of an ounce, for three or four mornings ſucceſſively. By this means he gently purged his patients, brought down their fleſh, kept them laxative, and freed them from their diſtempers, without raiſing any new diſturbance in the blood, or cauſing the leaſt diſorder in their bodies; for this admirable medicine, by ſtimulating only the glands of the inteſtines, derives a flux of humours into them, which it afterwards diſcharges by the *anus*, in the moſt calm and kindly manner, without leaving a prejudicial coſtiveneſs behind it.

## PROCESS L.

### *Exhibiting the analyſis of* TARTAR, *or its reſolution, into a* water, *a* ſpirit, *two kinds of* oil, *and a* fix'd alkali.

*The proceſs.* 1. F*ILL two thirds of a glaſs retort with ſmall entire pieces of choice white tartar; ſlightly lute on a receiver, and in a ſand-heat cautiouſly adminiſter the ſeveral degrees of fire. The ſubject will ſoon change its white colour to a brown, and the liquor that firſt comes over will be a copious, tart, bitteriſh, and penetrating water, with a mixture of ſpirit.* (2.) *Upon augmenting the fire to the ſecond degree, there will ariſe a whitiſh vapour, which turns to a more yellow, and bitter, but leſs acid ſpirit than what at firſt came over; together with a quantity, of a light, thin, black, penetrating oil, of a ſomewhat bitteriſh, but grateful taſte.* (3.) *By a fire of ſuppreſſion, a thick, black, ſtrong, fat, fetid,*

*fetid, and ponderous oil will be made to rise, and sink thro' the former liquors to the bottom of the receiver.* (4.) *There now remains behind an inflammable mass, that will constantly appear blackish in the retort, tho' urged with ever so violent a fire, of a fiery alkaline taste, and disposed to run in the air into oil of tartar,* per deliquium; *tho' tartar itself proves difficult to dissolve in water. But by being calcined in an open fire, it turns to a white ashes, which diluted in water, filtred and exhaled, yield a salt of tartar, that becomes blue, brown or red, by fusion, as formerly mention'd of fix'd alkalies.*

*The caution it requires, and the doctrine it affords.*

2. The juncture of the retort and receiver is here order'd to be but slightly luted, because there is otherwise the greatest danger of their bursting to pieces in the operation; tho' they were ever so large or capacious. For even the water which rises first is so exceeding subtile, penetrating, and forcible, as either to escape thro' a close and glutinous luting, or else to burst it, or to break the strongest glasses. But the oil that comes over second is still more subtile and powerful; so that tartar cannot possibly be distill'd without breaking the vessels, unless it be suffer'd to transude thro' the luting, as it constantly does, be the luting what it will, like water through a sponge. Indeed, it is the most penetrating thing that chemistry can produce; as the elder *Helmont* long ago observed. In our present process, therefore, 'tis safest to use the common lute, and not that of the philosophers, as 'tis called, which will suffer no acid spirit to pass it. Hence we see, that waters, spirits, acid salts, and vegetable oils, may, after a wonderful manner, lie close and latent in a dry form; and that all the essential salt, and native oils of a plant are not render'd volatile by vinous fermentation; whilst the acetous kind attenuates, dissolves, or consumes the whole thereof, and, together with the oil, turns the salt into a volatile, unctuous, saline, or acid liquor. Whence vinegar becomes a more powerful solvent than wine, which is in great measure spoiled and robb'd of its native salt or tartar; the more whereof it deposits, the softer it always proves; so that at length, having thrown off all its saline parts, it becomes that mild and oily liquor, call'd by the old woman in *Plautus*, *vinum edentulum*, toothless wine; as retaining no manner of pungency, or biting sharpness upon the tongue; which is always owing to the tartar contain'd in the wine. * This process likewise shews us, that we can form no true judgment of the nature and properties of a salt, from what remains thereof after distillation. Tartar, of itself, is an acid salt, and raises an ebullition with alkalies; but what it leaves behind, upon distillation, is perfectly of an

* Whoever has tasted of that old-hock in the great cellar at *Heidelberg*, which is there said to have been preserved for several ages, will have a very good notion of this *vinum edentulum*; as being perfectly smooth, flat, and oily upon the tongue, without any thing of that brisk flavour, or relish, to be found in the wines of later growths; so that a man can hardly be persuaded 'tis wine he holds in his mouth, when he goes to taste it.



alkaline

alkaline nature; tho' doubtless it did not exist under that form in the vine; and tho' but little acid comes from it in the operation.

*Virtues and uses of the productions.* 4. The oil which rises along with the spirit of our present process, is recommended by *Paracelsus* and *Helmont*, as an extraordinary remedy for cherishing, restoring, and relaxing the limbs contracted by cold; and for resolving the gross, concreted juices of the body, and even those hard knots occasion'd by severe fits of the gout. For which purposes it may be better fitted, by rectifying it along with the oil that runs off third; whereby it will be freed from a copious earth contain'd therein. This oil also has a wonderful property of recovering the lost odour of perfumes; or of increasing and fetching out this scent, by being mix'd therewith in a very small proportion: and I knew a certain artist, who had a peculiar way of thus bringing musk, ambergrease, and the richest sweets to themselves, with a few drops of the fetid oil of our present process; by which means also he greatly added to their virtues. The same thing has also been practised, to very great advantage, in the Duke of *Holstein*'s court. And the method of it seems agreeable enough to the common experiment of suspending such parcels of musk, civet, ambergrease, &c. as have almost lost the sweet scent for which they are valued, in a jakes for some time; whereby they are again brought to be perfectly odoriferous.

*Advantage of the process.* 5. The salt of tartar prepared after the manner of this process, may be obtain'd to greater advantage, and in a much larger proportion than in the common way of calcining it in an open fire. For when the tartar has been resolved into the several parts above-mention'd, it will, at last, by calcination, yield the strongest alkaline salt we know, and the fittest for chemical uses.

*Introduction to the chemical uses of the productions of fermentation.* 6. Having seen the effects of water upon vegetables, as applied thereto with the assistance of fire, and found, that it will dissolve their aqueous, saline, saponaceous, and gummy parts; it remains that we shew the effects of spirits, salts and oils upon the same. There are some vegetable substances, or bodies of a doubtful nature, that is undetermin'd as to the kingdom they belong to, very difficult to dissolve in spirit of wine, or the purest alcohol; such is amber, for instance (which appears to be a kind of fossil bitumen, though refer'd by us to the class of vegetables) myrrh, gum-guaiacum, gum-lac, gum-juniper, gum-hedera, dragons-blood, &c. which, tho' upon account of the grossness, or peculiar tenacity of their parts, they are not easily resolvable, may yet be made to afford their tinctures, by the due application of alcohol and fix'd alkali, together with the assistance of fire. On the contrary, there are others of a soft texture, that may readily be dissolved in spirit of wine, by a gentle heat, without the help of any alkaline salt, which wou'd rather serve to alter their natures, or impair their virtues, than open their bodies, and prepare them to give out their tinging parts to the *menstruum* with greater advantage. Such are all the purging roots, as those

thoſe of jalap, turbith, hermodactils, *&c.* and the inſpiſſated juices, as opium, euphorbium, benjamin; but particularly, all thoſe that contain a copious balſam, the tinctures whereof are prepared in the following manner.

# USES of the PRODUCTIONS OF FERMENTATION.

## PROCESS LI.

*Exhibiting the manner of extracting* TINCTURES, *with* RECTIFIED SPIRIT OF WINE per ſe, *from reſinous vegetables of a looſe texture; ſuch as* JALAP, SCAMMONY, *and* BENJAMIN.

1. *HAVING reduced crude jalap-root, for inſtance, to powder, put a proper quantity thereof into a tall vial, and pour upon it as much ſpirit of wine, once rectified, as will riſe two or three inches above it: keep the liquor gently boiling for four and twenty hours in a ſand-heat, or wooden furnace; and afterwards, let it ſtand for ſome time, in a quiet, cool place, that the* fæces *may fall to the bottom, and leave a fine tranſparent, unctuous liquor, richly impregnated with the virtues of the ſubject, of a colour between a yellow and a red, floating above them. This liquor is the tincture of the jalap; and ſhou'd be gently decanted from the ſediment, by a gradual inclination of the veſſel.* *The proceſs.*

2. 'Tis uſually very improper to filtre any of theſe tinctures in order to make them fine; becauſe the reſinous or gummy parts thereof will ſtay behind on the paper; and ſeldom all run through a ſtrainer, the pores whereof are any thing ſmall or cloſe. *A caution to be obſerv'd therein.*

3. The

*Its nature.* 3. The tinctures prepared after this manner are constantly found of a reddish colour. Thus, in our present process, tho' the powder of jalap is almost white; yet the tincture appears of a deep yellow, copiously mix'd with red. And thus likewise, the tinctures of opium, benjamin, or any of the blackest, or whitest bodies, provided they abound with oil, are always red: which is a plain indication, that their colour depends upon their oil; and accordingly, this being perfectly extracted from any subject, the remaining salt or earth, spirit or water, are always white or colourless. * The greatest part of these tinctures also turn white or milky, upon mixing with warm water; which proceeds entirely from the rosin they contain; and is the same thing that ascends, mix'd with oil, in the distillation of the waters of vegetables. But the tincture of saffron, and some other very subtile bodies, will retain their own red colour, when water is poured to them; which is a plain argument, that their oil is of a much more subtile nature, than that of the tinctures we just now mention'd.

*Virtue and uses of medicinal preparations obtain'd by its means.* 4. The tincture of benjamin, prepared according to this process, and mixed with a proper, or an equal quantity of fair water, turns into a white liquor, which, upon account of the use made of it, goes by the name of virgin's milk; † being frequently employ'd as an innocent cosmetic by the fair sex. And indeed, by repeated application, it will soften the skin, dilate its pores, and, by degrees, take away spots, or freckles in the face, and give a fine complection. It has also a very grateful aromatic flavour; and, upon account of its fine attenuated rosin, proves an admirable balsamic medicine in coughs proceeding from the taking of cold; being used along with some proper syrup, as that of violets, diacodium, or the like, in the quantity of twenty drops for a dose, to be repeated occasionally.

*Whence they proceed.* 5. The virtues of these tinctures arise partly from the spirit of wine employ'd in their preparation, and partly from those peculiar to the juices of the subject, which, so far as they are of a resinous nature, go to compose the tincture; without any mixture of their saline part, unless the *menstruum* were a low, or phlegmy spirit, capable, by its aqueous parts, of dissolving salts. Hence the tincture of jalap, taken in

* Sir *Isaac Newton* endeavours to prove, that bodies refract the rays of light which fall upon them, in proportion to the sulphur they contain; and by particular experiments has found, that those wherein the sulphureous principle abounds the most, refract them the strongest.

† The common *lac virginale* of the shops, is a liquor of a different nature from this, tho' used for the same purpose, but with much less safety; being prepared of alum-water and litharge boiled in vinegar, the mixture whereof makes an imperfect kind of white liquor; which being very cooling, astringent and repelling, is an improper cosmetic, and may do mischief, when applied to the face to strike in pimples, or cuticular eruptions, by blocking up the pores, checking the natural perspiration of the part, and throwing back the matter into the blood; and thus sometimes prove the cause of fevers, or other distempers; which inconveniencies are avoided, by the use of spirit of benjamin, made milky with fair water; especially, if preceded, or accompanied with proper evacuations.

the manner we ſhall hereafter mention, is one of the nobleſt hydrogogues hitherto diſcover'd; which, had *Hippocrates* but known, he wou'd have highly eſteem'd.

6. 'Tis here to be carefully obſerv'd, that tinctures of theſe reſinous vegetables of a lax texture, eſpecially if they abound with ſalt, are ſometimes drawn to the beſt advantage, with weak ſpirits, or aqueous menſtruums. For ſometimes the purgative virtues of ſuch bodies reſide in their ſaline parts; upon which account, 'tis often very proper to let down our ſpirit of wine with water, in order to obtain the full force and virtue of ſimples; or ſometimes even to boil them in nothing but pure water. The alcohol of wine, we ſee, diſſolves only the reſinous and oily parts of vegetables, and leaves the ſaline untouch'd; which, however, are eagerly taken up by water. So that, in ſome caſes, it may be highly diſadvantageous to employ pure alcohol in the extraction of tinctures. This is an obſervation of very great moment; for which we are beholding to ſome induſtrious members of the *Royal Academy* at *Paris.* And hence we may eſtabliſh it as a rule, that water is the proper *menſtruum* for ſaline ſubjects, alcohol for ſuch as are reſinous, but a diluted ſpirit of wine for thoſe that conſiſt of ſaline, as well as unctuous parts. Sena, by being infuſed in high rectified ſpirit of wine, communicates nothing, or very little, of its purgative virtue thereto; whilſt water wou'd extract it fully. On the other hand, ſcammony wou'd ſcarce open at all to water; but is totally diſſolved in ſpirit of wine. And our preſent ſubject, jalap, whoſe cathartic virtue reſides both in its reſinous and ſaline part, requires a ſpirit lower than alcohol; tho' it muſt, however, be once rectified, to deprive it of its acid, which wou'd otherwiſe greatly obſtruct, or weaken the purgative power of the root.* And hence we are ſhewn the reaſon why the roſin of jalap, which is extracted from the ſubject by pure alcohol, proves leſs cathartic than that gain'd from it with a weaker ſpirit. For even after the alcohol has extracted its roſin, and ſaturated itſelf therewith; an aqueous menſtruum, poured upon the remains, will fetch out the ſalt, which is alſo purgative, and ought to be mix'd with the roſin, to gain the full force of the ſubject.

*Directions, as to conducting the proceſs.*

* 'Tis a deſirable thing in pharmacy, to be able to ſuit the *menſtruum* to the ingredients, ſo as to extract the parts required, without any mixture of thoſe that are foreign to the deſign of a compoſition. This cannot ſometimes be done but by the aſſiſtance of two or three different menſtruums, put to work upon different ingredients. But the common diſpenſatory-writers have ſo little regard to theſe cautions, that 'tis generally much ſafer to truſt nature, and take the crude ſimples as ſhe affords them, than rely upon common preparations, contrived at all adventures, or without a due knowledge of their nature, the different parts whereof they conſiſt, or how to extract the particular virtues required from them. By which unskilfulneſs in pharmacy, we ſometimes ſee the purgative ſimples deprived of their natural correctors, and ſent with their drawn *ſpiculæ* into the body, to ſtab and wound the inteſtines, without the leaſt oppoſition.

Hence

*The Doctrine it affords.* 7. Hence we may inform ourselves, that inflammable spirits of wine extract from vegetables those parts only, which by distillation are made to come over and appear in the form of oil; and which, when they spontaneously ouze out from plants, and thicken or grow hard by the sun's heat, go by the name of balsams or rosins. So that the tinctures of vegetables appear to be no more than a mixture of their oily and spirituous parts.

## PROCESS LII.

### *Exhibiting the manner of preparing* Tinctures *with* ALCOHOL per se; *by an* EXAMPLE *in* SAFFRON.

*The process.* 1. PUT *of the finest dry saffron into a very tall glass-vial, made perfectly pure and dry; pour upon it about four or six times its own quantity of alcohol of wine, rectified* per se, *and then digest them together, with a gentle heat, for eighteen or twenty hours; whereby the alcohol will be tinged of a very beautiful yellow. When the vessel is thoroughly cooled, gently separate the tincture from the saffron, pour a fresh parcel of alcohol upon the remains, and digest as before, till the spirit has imbibed all the yellow part of the subject, and leaves only the stamina thereof, perfectly white, at the bottom of the glass, and deprived of all their natural taste and scent. Then the several gold-colour'd liquors, being mixed together, give the tincture of saffron in great perfection.*

*Its Nature* 2. This process is to be perform'd with alcohol, rectified *per se*, and not that distill'd from fix'd alkali; because the latter wou'd destroy the tender structure of the subject, or change its nature; whilst the perfectly pure and unmix'd inflammable spirit, here employ'd, barely extracts its oily or sulphureous part, colours itself therewith, and thereby becomes enrich'd with the taste, odour, and virtues of the saffron, yet without partaking of its salt; which can never be dissolved by alcohol.

*Doctrine.* 3. If this tincture be drop'd into water, it does not make it appear any way thick or turbid; but barely turns it of a fine yellow, or gold-colour: which certainly proves that the oil contain'd in the chives of saffron, is too much attenuated, or broke too fine, to form or concrete into rosin.

*Medicinal virtues and uses of the production.* 4. The medicinal virtues of this tincture of saffron are very many; and when properly used, it proves an excellent cordial, as containing a very fine and subtile oil. But prudence is required in the administration; otherwise it may easily become poisonous. If a person, unaccustom'd to the use of saffron, should take but a single dram of the ex-

extract that may be prepared by exhaling away this tincture over a very gentle fire; he would first, for a few days after, appear wondrous joyful, and then run into a mirthful kind of madness, attended with an almost continued fit of laughter; but at length he wou'd fall into a lethargy, or an apoplexy, to the no small danger of his life. I myself knew a worthy professor here at *Leyden*, who falling into a fit of hypocondraic melancholy, attended with a great dejection, or sadness of mind, and having the constant use of this tincture prescribed him by his physicians, was thereby rendered perfectly childish or silly; and narrowly escaped with life.

## PROCESS LIII.

*Exhibiting the manner of preparing* TINCTURES, *with* Alcohol *and* Fixed Alkali, *from subjects of a strong texture, or hard, glutinous nature, such as* Amber, Myrrh, Gum-lac, *&c.*

1. *REDUCE myrrh, for example, that is not too fat or unctuous, into a fine powder, and mix it up well with oil of tartar,* per deliquium, *into a soft kind of paste; then dry it in a glazed vessel, or one of glass, over a gentle fire, till it becomes a dry powder again: place this powder in a cool cellar, and there suffer it to run by the moisture of the air; dry it again, and repeat the process with fresh oil of tartar, till all the myrrh is at length so opened, that it will perfectly dissolve in alcohol of wine. (2.) Upon the powder thus prepared, gently dry'd, and put into a very tall, chemical vial or bolt-head, pour enough alcohol, rectified from fix'd alkali, to swim three or four inches above it; and then let them boil together, over a soft fire, in a wooden furnace, for the space of four and twenty hours; after which time, the vessel being suffered to cool of itself, gently decant the liquor from the* fæces *at the bottom, and you will thus gain a fine, transparent, tincture of myrrh.* *The process.*

2. This is the best method I am acquainted with, of obtaining tinctures from hard, gummy bodies, remarkable for the tenacity of their parts; and what I found to be better than any of the other numerous ways which I have tried; as expeditiously affording a perfectly beautiful and transparent tincture, highly saturated with the unctuous parts of the subject; whilst many of the other methods require a longer time, and are apt to foul the tinctures, and make them turbid. By this means we can presently draw the tincture of amber; which, in *Helmont*'s method, requires a week's digestion to obtain. And thus, as we have seen, myrrh may be easily dissolved in alcohol of wine; tho' there are many who pretend that it can never be brought to afford any tincture at all: so that they would *Its excellence.*

 have

have us believe that *Elixir Proprietatis* is nothing more than a tincture of the aloes and ſaffron, without taking up a grain of the myrrh preſcribed in its compoſition. This is always to be obſerved as a general rule in the preſent proceſs, that the harder the ſubject is to diſſolve, the finer it muſt be ground, the oftner moiſtened with the oil of tartar, dry'd and run into a liquor, and again the longer digeſted with the ſpirit; whereby at length the tenacity of its parts will be entirely deſtroy'd, and its texture broken. But, except in extraordinary caſes, when the courſe of operations has been thrice repeated, the body will be ſufficiently opened to diſſolve in the ſpirit. Thus even gum-hedera, tho' ſo difficult of ſolution, will be ſo penetrated, have its parts ſo ſeparated, and its vinulum ſo broken and deſtroy'd, by going three or four times through the circle, as readily to diſſolve in alcohol of wine. The glaſs vial, or bolt-head, uſed in this proceſs, is ordered to be very tall; ſo that if the neck be ſlender as well as long, it may well enough be kept open at the top, without danger of the ſpirit's exhaling at the mouth thereof; becauſe in ſuch veſſels the air will perform the office of a ſtopple, and keep in the fine vapor that ariſes in the operation.

*Nature and medicinal virtues of the productions thereof.*

3. Whatever is extracted by the menſtruum from the ſubjects of this proceſs, is totally inflammable: which lets us ſee the juſtneſs of the eſtabliſh'd rule in chemiſtry, that alcohol of wine takes nothing up from vegetables, but what is of its own nature; and therefore principally diſſolves only their oily, reſinous, and ſpirituous parts. The virtues of theſe tinctures are to be learnt from the natures of the ſeveral ſubjects that afford them, together with that of the ſpirit; tho' they are here greatly exalted by the operation, as well as the menſtruum. In general, they are balſamic, vulnerary, healing, corroborating, exhilerating, deobſtruent, and, when taken in a large doſe, purgative. They greatly reſiſt putrefaction in the body, brace up the ſlackened nerves, ſerve to drain off ſuperfluous humors, and cure diſtempers proceeding from a cold, viſcid, or pituitous cauſe in the juices, or inactivity on the ſide of the veſſels; and are alſo of very great uſe in various caſes of chirurgery. They may conveniently enough be taken with a glaſs of *Spaniſh* wine, or the like, ſoft, ſpirituous vehicle, in the quantity of a dram or two, twice or thrice a day.

4. Thus the tincture of gum-lac, prepared after this manner, is the beſt medicine hitherto known in that ſpecies of the ſcurvy which proceeds from putrefaction, where the veſſels are weak, infirm, or in part eat away by the acrimony of the diſtemper, and the breath ſmells fetid. 'Tis alſo excellent in caſe of the rickets in children; being given in the quantity of a few drops, twice or thrice a day. The gum itſelf has a bitter flavour, is ſomewhat aſtringent upon the tongue, and contains an oil, that it will not readily communicate to ſpirit of wine by coction; but may be advantageouſly fetched out by the treatment abovementioned.

5. The

5. The tincture of amber, prepared in the manner of our preſent proceſs, is a noble medicine in hyſteric and hypochondriacal diſorders, lax conſtitutions, and where the nerves are weak and unbraced; as likewiſe in all caſes where a purulent matter is formed in the body, or any foul, internal ulcer wants to be cleanſed, in the epilepſy, and the *fluor albus*; upon all which accounts it was juſtly recommended by *Helmont*, who greatly increaſed his reputation by its means. And I myſelf knew a phyſician, who became very famous from this ſingle medicine; and continued in great repute ſo long as he kept it a ſecret. It may be taken in the quantity of a hundred drops, thrice a day, in any convenient vehicle. But in putrid fevers, or any other acute diſtemper, it ought not to be uſed; becauſe it would there do miſchief. 'Tis very ſerviceable, being applied externally to ulcers, which it excellently deterges when they are foul, and eſpecially ſuch as are venereal. And ſome have recommended it as a great preſervative, to procure a continuance of health and long life.

6. Our tincture of myrrh is likewiſe an admirable medicine, in all caſes, where both the *primæ* and *ſecundæ viæ* are to be opened, any corrupt humor to be deterged, or the juices ſtand in need of a balſam to preſerve them from putrefaction. Hence it proves highly ſerviceable when ulcers are ſeated in the kidneys, lungs, *uterus*, &c. 'Tis of wonderful efficacy in all the diſtempers peculiar to women, that proceed from a watery cauſe, or too great a laxity of the veſſels; as particularly in that exulceration of the veſſels which cauſes the *fluor albus*. In the venereal diſeaſe 'tis a very effectual remedy, as ſtrongly reſiſting and cleanſing away the putrefaction which that diſtemper brings upon the fluids and ſolids. It alſo proves of ſervice in tertian and quartan agues. Its external uſes in chirurgery are no leſs conſiderable than its internal in other parts of medicine. It powerfully deterges fiſtula's, and foul, ſinuous, or venereal ulcers; and when the bones are carious, and require exfoliation, as frequently happens from the venereal taint, no better remedy can be employ'd. In the ſcurvy, attended with a corruption of the gums, and a loſs of their ſubſtance, it ſerves to ſtop the growing evil, and preſerve them from farther injury. In fine, the medicinal virtues of myrrh have ever been eſteemed ſo great, that all antiquity was employ'd in finding out ways to reſolve it, tho' not with any extraordinary ſucceſs; for 'tis exceeding difficult of ſolution: and if taken into the body in form of a powder, it is not digeſted by the force thereof, but comes away again crude, as it was received. Hence *Helmont* tells us, in his treatiſe of *Long Life*, that he who can render myrrh ſoluble by the body, has the ſecret of prolonging his days. And, indeed, there ſeems to be ſome truth in the aſſertion; ſince it cures the moſt deſperate ulcers, and prevents all manner of putrefaction in the human body and animal ſubſtances. Thus, were a bird, for inſtance, or any other ſmall animal, to be dipt ſeveral times ſucceſſively in our tincture of

myrrh; it would soon be perfectly penetrated or embalmed thereby, and turned to a kind of *Egyptian* mummy, capable of remaining entire for numerous ages; which is an operation that in the common way of embalming cannot be so well performed in the space of several months.

## PROCESS LIV.

### *Exhibiting the manner of making* CATHARTIC POTIONS, *with the productions, or resinous Tinctures, of the fifty first* PROCESS.

*The process.* *WITH any resinous, purging tincture, prepared after the manner of our fifty first process, mix twice its own quantity of some purging syrup; and you will thereby obtain an excellent* cathartic potion, *that strongly and suddenly discharges aqueous humours out of the body, and may be given to great advantage in cold or leucophlegmatic constitutions.*

*Virtues and uses of the productions.* 2. Thus if three drams, or half an ounce of the tincture of jalap be mixed up with six drams, or an ounce of the syrup of buck-thorn, syrup of rhubarb, or the solutive syrup of roses, prepared either with or without sena; it excellently moves, and suddenly draws off the collected lympha in a dropsy, and discharges it by stool. The like may be said of the tincture of scammony, tho' this is of a stronger, and somewhat hotter nature; and the same holds true of all the resinous carthartics, turbith, hellebore, colocinth, hermodactils, *&c.* But a proper regimen is to be observed, when such violent medicines are taken. These resinous tinctures should never be mixed up along with waters for exhibition; because by this means their rosin would be precipitated, and, in swallowing of them down, stick to the the inside of the mouth, so as to prove very nauseous, and exceeding difficult to get off.

CHE-

# CHEMICAL HISTORY *of* *ROSINS.*

## PROCESS LV.

*Exhibiting the manner of obtaining* ROSINS *from the productions of the fifty first and fifty third* PROCESSES.

1. WHEN *the resinous tinctures of our fifty first and fifty third process have, by long standing at rest, in a cold place, perfectly purified themselves, and let fall their* fæces *to the bottom of the containing vessels; if any one of them be distilled with a gentle heat, in a glass retort and receiver, till three fourths of their original quantity is come over; and clear, cold, rain-water be pour'd upon the remainder, in the proportion of four or six to one; the whole mixture will immediately turn milky, thick, and turbid; upon which a yellow, unctuous, and soft clammy matter will be precipitated, or let fall to the bottom, as being by the water set free from the alcohol wherein it before remained dissolved.* (2.) *Let the whole of this mixture be distilled again, or committed to a low and wide glass vessel, and exhaled away over a slow fire, till either the ascending vapor, when condensed, ceases to run in oily rivulets, or till all the spirit is evaporated, and the remaining water becomes clear, which being poured away when cold, the yellow, tenacious, unctuous substance is found fix'd to the sides and bottom of the vessel.* (3.) *Pour fresh water upon this viscid, adhesive matter, exhale it away again, and repeat the operation, till not the least scent of the spirit can be perceived in the remainder, which, when perfectly cold, dry, and kept for some days, will prove a transparent, brittle, or pulverable body, of a colour between brown and yellow, that will readily melt with heat totally burn away in the fire, perfectly dissolve in oil, and alcohol, but remain untouched by water; which properties constitute it a rosin.* *The process.*

2. There are three ways in which rosins are prepared; *viz.* that of nature, which converts the natural vegetable balsams into rosins, by means of the sun's heat; that of our present process; and that other artificial way, whereby the like balsams are freed from their liquid parts with a gentle fire. All rosins appear much of the same colour, which is either a light or dark yellow; share the same properties, and differ from gums in nothing but this, that they will not dissolve in water; which property, therefore, sets the difference betwixt a gum and a rosin. Sulphur passed for a rosin with the ancients; and, indeed, it seems nearly allied thereto; bating for its want of transparency and indis- *Nature of the productions.*

diſpoſition to open in alcohol of wine; tho' the addition of a little fix'd alkali will make it readily diſſolve therein. The ſubjects of this proceſs ought to be ſuch as are dry; otherwiſe the alcohol employ'd to extract their roſin, will unite with their aqueous parts, and then barely act like unrectified ſpirit of wine.

*Their virtues and uſes.*

3. Almoſt all theſe roſins have a purgative virtue; tho' obtained from bodies that were not purgative themſelves. Thus guaiacum-wood, for inſtance, even after it has been boiled and dried again, will give out a roſin to alcohol of wine; which, as I have found by experience, proves a very mild, and excellent cathartic; tho' the wood itſelf is conſtantly diaphoretic, and no ways purgative. And after the ſame manner roſins may be obtained from any kind of vegetable ſubſtances. When any of them are deſigned for internal uſe, as cathartics, 'tis proper to grind them with twice their own quantity of ſugar, or to diſſolve them in a little of the yolk of an egg, and wrap them up in ſomething that may let them be conveniently ſwallowed, without ſticking to the internal parts of the mouth, where they might prove troubleſome; as being of their own nature viſcid, inflammatory, and cauſtic or corroding. A ſmall draught alſo of ſome proper ſpirituous liquor ought to be taken down immediately after them, in order to diſſolve their texture, and make them mix with the juices in the ſtomach. Theſe roſins are very ſtrong hydrogogues; but no ſmall danger and uncertainty attends their exhibition; as being apt to occaſion hypercatharſes, or purge the patient who takes them, even to death. For by reaſon of their tenacity, they ſometimes run together, and ſtick faſt to the inteſtines, which they vellicate, burn, and corrode in ſuch a terrible manner, as to occaſion a perpetual *diarrhœa*, with intolerable gripings. This is more frequently the caſe in perſons of a dry habit of body, who have not moiſture enough to dilute and waſh theſe roſins away from the ſtomach, and the other parts they lodge upon, and carry them clear out of the inteſtinal tube. But in ſuch bodies as abound with acids in the *primæ viæ*, their force is thereby ſo weakened, as ſcarce to operate at all. 'Tis very remarkable, that any of the purging roots being infuſed in vinegar, or any acid ſpirit, loſe their virtue. And thus when cream of tartar, or any other acid of the ſame nature, is mixed or taken along with jalap, ſcammony, or the like reſinous cathartics, it greatly abates of their force. Our purgative roſins, alſo, are found inactive, or to have but very ſmall effects, if the body abounds with aqueous humors, or hath only a ſmall proportion of bile. In which caſe they ought always to be mixed with ſugar, that they may the more readily unite with the water to be purged off: but when the bile is a predominating humor of the body, they are readily diſſolved thereby, and ſo come to act with very great violence.

*The Doctrine afforded by the Proceſs.*

4. Hence we underſtand, that alcohol of wine diſſolves the balſam, or harden'd oil of vegetables; which it lets go in water: and by theſe two operations, *viz.* ſolution and precipitation, we obtain their reſinous, or

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unctuous part; wherein their purgative virtue principally reſides; and of which they being once deprived, will ſcarce afterwards operate as cathartics. Thus when the roſin has been extracted, by ſpirit of wine, from jalap, ſcammony, euphorbium, elaterium, colocynth, *&c.* what remains behind of them will hardly move the body, tho' they would purge violently before they are thus robb'd.

# CHEMICAL HISTORY *of* *ESSENTIAL EXTRACTS.*

## PROCESS LVI.

*Exhibiting the manner of making* ESSENTIAL EXTRACTS *of the moſt coſtly aromatics, with pure alcohol prepared without alkalies; by an example in* SAFFRON.

1. *MAKE a tincture of ſaffron, with pure alcohol prepared* per ſe, *in a tall glaſs, after the manner of the fifty-ſecond proceſs, and pour off the clear liquor by gentle inclination; put freſh alcohol to the remainder, digeſt again, and repeat the operation whilſt the ſpirit will tinge itſelf thereon, or acquire any virtue from the ſaffron.* (2.) *Then mix the ſeveral parcels of tincture together; and with a gentle heat, ſcarce exceeding that of a healthy man, diſtil off ſo much of the ſpirit in a low, wide-mouth'd veſſel, as to leave the tincture at the bottom of the conſiſtence of oil, which will now become the eſſential extract of ſaffron* *. *The proceſs.*

2. The moſt delicate, tender, odoriferous, and coſtly ſpices and perfumes, as cinnamon, mace, nutmeg, cloves, ambergreaſe, musk, *&c.* may by this treatment be made into tinctures to advantage; the firſt part of the proceſs, *viz.* the extraction of the tincture, being repeated till the bodies will communicate no manner of ſmell, taſte, or colour, to the ſpirit; which will, therefore, remain poſſeſſed of their full virtues. For theſe ingredients are not endowed with a groſs reſinous ſulphur; but one that is much more ſubtile, delicate and piercing; ſo as intimately to unite with pure alcohol. *How practicable to advantage.*

3. Theſe extracts are admirable in their virtue; which is extremely diffuſive, penetrating and correſponding to that of the ſubject; but here found in *Virtues and uſes of the productions thereof.*

* The ſpirit which aſcends in the diſtillation, is the ſpirit of ſaffron; an excellent and very rich cordial.

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a much higher degree; the form containing the preſiding ſpirit and native balſam thereof. The extract of ſaffron, or opium, *&c.* as it were in an inſtant ſpreads its virtue through the whole body; or much more ſwiftly than the drugs themſelves. And ſome experiments, made with this view in our univerſity of *Leyden*, ſeem to confirm the truth of the aſſertion. For three grains of crude opium being here given to a man, the time it cauſed him to ſleep was diligently obſerved; after which, the like quantity of the extract of opium being exhibited, the perſon was found by this to be thrown into a much deeper ſleep, of longer continuance. And, indeed, two or three drops of the extract of opium, thus prepared, will procure reſt, and eaſe the moſt grievous pain, in a ſurprizing manner. I have myſelf made an extract of ſaffron, one drop of which being mixed with a large proportion of wine, gave it an exceeding grateful ſcent, and taſte, as well as a moſt beautiful colour; which ſhews the diffuſiveneſs of its virtue. In effect, it is ſurprizing how great a cordial this extract is; and how greatly it exhilerates, tho' taken in a very ſmall quantity. After the ſame manner, if *cantharides* be brought into an extract with alcohol, two or three drops of it, taken in wine that is free from acidity, will, in a few minutes time, give ſuch a ſtrangury, or difficulty of urine, and ſo great a convulſion of the bladder, as to cauſe an excretion of its mucus, and a bloody water.

4. If theſe extracts, by the continuance of heat, ſhould be brought to a higher conſiſtence, ſo as at length to become brittle, and capable of being reduced to a powder, they might then be mixed up with ſugar, and thus poſſeſs all the virtues of their ſubjects in a portable form. I know a chemiſt who by this method of managing theſe extracts, made a great variety of medicines, greatly to his own profit and reputation. He took the extracts of ſpices, prepared in the manner of our preſent proceſs, and with a gentle fire reduced them almoſt to a ſtate of dryneſs; then, by adding a little dry ſugar thereto, which drank up the remaining moiſture, brought them into the form of a powder, to which, by means of a little cinnabar, he gave a beautiful colour; and thus compoſed very elegant powders, of uncommon virtues and efficacy. And of this kind is that powder which was firſt prepared at the court at *Zell* in *Germany*, and, upon account of its colour, called by the *Italians*, *Pulvis del oro*, tho' there is no gold at all in the compoſition.

*Doctrine it affords.*

5. Hence we ſee that the virtues of aromatics reſide in that part of them which is diſſolvable and preſervable in alcohol; and which, when once ſeparated from the drug, leaves nothing but a ſceleton, or unactive matter behind it, deſtitute of the ſcent, taſte, and virtues of the plant.

*The cautions required in exhibiting the productions.*

6. Theſe extracts are not to be given without a deal of caution; and ſeldom in a doſe greater than that of a few drops; which ſhould rather be repeated the oftner, than to run the hazard of giving too much at once; otherwiſe, inſtead of ſtrengthening and recruiting the patient,

the

the texture of his blood will be entirely broke and diſſolved thereby. They are given to the beſt advantage in a glaſs of ſome unctuous wine, ſuch as *Spaniſh* or *Canary.* I am always cautious of giving more than half a grain of the extract of opium, for inſtance; yet dare, upon occaſion, venture to order three grains of crude opium for a doſe. So the extract of ſaffron, given too freely, might be of dangerous conſequence; but will be of very great ſervice in caſes which require a ſudden and extraordinary fluſh of ſpirits.

# CHEMICAL HISTORY *of* *QUINTESSENCES.*

## PROCESS LVII.

*Exhibiting the manner of preparing* QUINTESSENCES, *with eſſential oils, and pure alcohol; by an* EXAMPLE *in the eſſential* OIL OF FENNEL.

1. *UPON a proper quantity of any eſſential oil, as that of fennel, for inſtance, pour twelve times as much, or more pure alcohol prepared* per ſe; *mix them together, and they will inſtantly unite into one ſimilar liquor, which is the quinteſſence required.* *The proceſs.*

2. Care muſt be had in this operation, that not a drop of water remains either in the oil, the alcohol, or the veſſel; for this wou'd foul the liquor, and turn it milky. And if, after the mixture is perfectly made, water be poured to it, the whole will be diſturbed, and become white; all the alcohol immediately joining itſelf to the water, and letting go the oil, which will now either float on the top, or ſink to the bottom, according to its ſpecific gravity. *The caution it requires.*

3. This method of diſſolving oils in alcohol was utterly unknown to the ancients: and, indeed, a very celebrated chemiſt has lately denied the poſſibility thereof, without the aſſiſtance of alkalies. But our preſent proceſs furniſhes us with an undeniable example, that oils may be ſo perfectly diſſolved in pure alcohol, prepared without alkalies, as totally to diſappear therein, and compoſe one uniform liquor with the ſpirit. And for farther confirmation hereof, we may try it again with two or three drops of the eſſential oil of cinnamon, which is known to be ſo heavy, as to ſink even in ſalt-water; yet even this ponderous oil being *Its certainty confirm'd.*

let fall into pure alcohol *per se*, will, as soon as ever it begins to descend therein, so perfectly mix itself with the spirit in its motion, as that every single drop of the whole shall contain some portion of the divided oil, as is manifest by the smell and taste of the cinnamon therein.

*Its excellence, and uncommon use.* 4. If the quintessences of this process be several times digested, cohobated and distill'd again, the oil therein will, at length, be broke so fine, as, like the alcohol itself, readily to mix with water. And this, perhaps, is as noble an experiment as any in chemistry; tho' at the same time we must own it is chargeable. Thus, if I wou'd have an essence of cinnamon, that shou'd be potable in water, I take a dram, for instance, of the pure essential oil of that spice, and mix it with two ounces of pure alcohol *per se*; then, either by digesting them together, for a year, with a proper heat, or by repeated distillation, I bring the two to unite so permanently, and so intimately, as to mix with water, or the humors of the body; for, by this means, the repeated strokes of a gentle fire grinds and attenuates the parts of the oil to the size of those of the spirit, with which it therefore forms one homogeneous and unchangeable liquor, having the taste, scent, and virtues of cinnamon, as perfect as if the oil had been fermented with the alcohol; which, therefore, shews us another method of converting oils into spirits.

*The doctrine it affords, with the uses thereof.* 5. We are now given to understand the chemical effects of alcohol upon spirits, rosins and oils; and the affinity there is between it and oil, as it is a menstruum to all kinds thereof. Hence we likewise learn the manner of dissolving, diluting, and adulterating of oils; and at the same time adding to their taste, scent, and fineness. Hence also we are let into the nature of an oily spirit, and the methods of discovering any adulteration of that kind, by the admixture of water. Essential oils, we see, may easily be adulterated with alcohol; because they readily and intimately unite therewith: and at the same time that it dissolves them, it increases their virtues, and makes them stronger, more aromatic and subtile. But if there were any oil perfectly destitute of taste, scent and colour, it might be used to adulterate the richest essential oils, without a possibility of discovering the fraud. But there is no such known at present; or if some may, at first sight, appear to be of this kind, they soon turn rancid. And therefore, alcohol is the only thing that can be successfully employ'd in the adulteration of essential oils: and this cheat may be detected, as was said before, by the milky colour, and separation that will be procured when water is poured to such a mixture. For the like will not happen when the oil is pure and unmix'd.

*Medicinal virtues of the productions.* 6. These quintessences are of wonderful medicinal virtues, as is easy to imagine from their composition; being the mixture of an essential oil with a pure vegetable spirit: so that they may not improperly be called vegetable sulphurs, made potable, and raised to their utmost degree of power and efficacy. They are, doubtless, some of the most excellent and specific

ſpecific medicines that can be obtain'd from vegetables; as retaining in an exalted degree of perfection, all the virtues of the plant whoſe oil they were made of. And farther than this, it is ſcarce poſſible to riſe in the vegetable kingdom.

## PROCESS LVIII.

### *Exhibiting the manner of preparing the* QUINTESSENCES of ASIATIC *Roſins; by an example in* CAMPHIRE.

1. *Reduce that dry oil, the roſin of* Aſia, *otherwiſe called camphire, to a powder, or conſiderably ſmall parts, and pour thereon any quantity of pure alcohol, or ſpirit of wine; this will ſoon perfectly diſſolve the camphire, like ſo much oil, whilſt the whole appears one uniform liquor.* (2.) *But if water be now poured into the ſolution, the mixture will preſently become turbid, white, and give out the camphire in its priſtine form. And this wou'd be the conſequence if the experiment were a hundred times repeated, or freſh ſolutions and precipitations made; without any alteration in the native form or virtue of the camphire.* *The proceſs.*

2. Camphire being nothing but the eſſential oil of *carduus benedictus*, or the camphire-tree growing in *Aſia*, it is plain from our preſent proceſs, that what is a mere oil in the hotteſt regions, may appear like ſulphur, as to dryneſs, in the colder; and therefore, that oils, as well as water, may paſs into a kind of ice. As to the manner of the formation of camphire, we have frequent examples of it in the diſtillation of plants; the oil whereof ſometimes adheres to, and blocks up the worm: but if it be clear'd out, and expoſed to the cold air, it will there grow hard like ice, and turn to a kind of camphire; which, by diſtillation, wou'd appear under the form of a ſpirit. But the camphire of *Aſia* is a roſin *ſui generis*, and not like the concreted oils of other countries. *The doctrine it affords.*

3. The quinteſſence of this proceſs, prepared with camphire, is a very balſamic medicine, and powerfully reſiſts putrefaction in the body. 'Tis alſo an excellent coſmetic, in caſe of an ulcerous skin; and admirably preſerves from corruption ſuch ſmall animals as are ſuſpended therein. *Virtues of the production.*

## PROCESS LIX.

*Exhibiting the manner of preparing dry* QUINTESSENCES, *from the liquid ones and the eſſential extracts of the fifty ſixth* PROCESS.

*The proceſs.* 1. *TO four ounces of loaf-ſugar finely ground, and thoroughly dry'd, pour three drams of any liquid quinteſſence, compoſed of three parts oil, and one of alcohol; add one dram of the extract of the ſame kind of aromatic with that of the liquid quinteſſence, and in the manner of the fifty ſixth proceſs, and mix them well together, by grinding them in a dry glaſs mortar, without admitting the leaſt moiſture. Diſtil the mixture in a glaſs cucurbit, with a heat no greater than that of a man in health, till the alcohol of the liquid quinteſſence is come over; and what is then left behind will be a dry quinteſſence, which ought to be kept in well-cloſed veſſels of glaſs.*

*Medicinal virtues, and uſes of the productions.* 2. The alcohol in the liquid quinteſſence is of uſe in this operation, by opening the body of the oil, and making it unite with the ſugar. And after the ſame manner is the famous *golden powder* prepared, tho' ſold at an exorbitant price, with the addition of a little cinnabar to heighten its colour. The form of theſe quinteſſences is beyond even that of the *elæoſacchara*, and renders them principally ſerviceable to travellers and ſailors; as being very convenient for carriage, and powerful in their operation; a very ſmall quantity alſo ſerving for a doſe. Thus, if a traveller ſhou'd in his voyage be at any time ſeized with a dyſentery, for inſtance, a quantity of the dry quinteſſence of opium, no bigger than the head of a moderate pin, taken in a glaſs of wine, might readily and commodiouſly effect the cure, without other aſſiſtance. But for a warm, anodyne, portable cordial, of great efficacy in diſtempers proceeding from cold, and attended with weakneſs, take the eſſential oil of cinnamon, citron-peel, and orange-peel, of each one dram, of the oil of mace half a dram, that of cloves ſix drops, that of rhodium eight drops; and make all theſe into a liquid quinteſſence, or oily ſpirit, with a dram of pure alcohol *per ſe*; and thus there will be obtain'd as effectual and grateful a cordial, as any in the art of medicine. But to convert this into a dry, anodyne quinteſſence, take of choice opium, gently dry'd, one dram, and four drams of ſaffron; and with pure alcohol, prepared without alkalies, make an extract, in the manner deſcribed in the fifty ſixth proceſs; then draw off the moiſture till there remains of the extract no more than about four drams, which are to be mix'd with the liquid quinteſſence juſt now ſet down, in the manner of the preſent proceſs. This preparation being taken in the quantity of a ſingle grain, up to ten, if there ſhall

ſhall be occaſion, is ſuch an immediate anodyne cordial, as nothing can exceed, being taken in a glaſs of *Spaniſh* wine. And after this manner the preparation may be varied at pleaſure, within the limits of the proportions aſſign'd.

# CHEMICAL HISTORY *of* *Medicated* Aromatic *SPIRITS*.

## PROCESS LX.

*Exhibiting the manner of preparing* ſimple, medicated, aromatic ſpirits, *from recent vegetables; by an example in* Rosemary.

*The proceſs.*

1. *TO a proper quantity of the freſh gathered leaves of roſemary, pour eight or ten times as much ſpirit of wine, that has been once rectified *; and diſtil them either in a glaſs cucurbit, or copper alembic, ſo long as the ſpirit comes over, or any oily veins appear in the head, or upper part of the glaſs; and what thus runs off will be the ſimple, medicated, aromatic ſpirit of roſemary, otherwiſe called the Queen of* Hungary'*s water; which being cohobated, or again diſtill'd from ſuch leaves, or flowers of roſemary, will become the better and richer.*

*Nature, and medicinal virtues of the production.*

2. This ſpirit is an improvement upon the ſimple waters of vegetables, tho' no more than a ſolution of the fine volatile, or eſſential oil of the plant in ſpirit of wine; and accordingly it turns milky, like the quinteſſences of the fifty ſeventh proceſs, when water is mix'd therewith. In effect, this ſpirit ſcarce differs from that; being a mixture of ſpirit of wine with an eſſential oil, which may be readily ſeparated by the addition of water; ſo that its general virtues and uſes are already mention'd under that proceſs. A like ſpirit may, by the ſame means, be obtain'd from other recent vegetables; ſo as to anſwer various intentions in the cure of diſeaſes. Thus an hyſteric, cephalic, or a ſtomachic, or a cardiac ſpirit, may be obtain'd from plants endow'd with ſuch kind of virtues. Thus the ſimple ſpirit of the roots of garden-angelica, cohobated thrice, or till only two thirds of the original quantity of ſpirit of wine remains, is an admirable medicine in aſthma's proceeding from a cold cauſe, or in a too great ſtraitneſs of the cheſt;

* In order to make good hungary-water, the proportion of the ſpirit ſhou'd be leſs, in reſpect of the roſemary-flowers, that it may be fully ſaturated with the fine aromatic oil, and native ſpirit of the plant.

being

being taken in a proper quantity, early in the morning, and ſweeten'd with a little ſugar or honey. But the ſmall and tender parts of the roots are beſt ſuited to anſwer this purpoſe, as having much more virtue than the groſſer. And if the diſtillation be duly carried on, the ſpirit that comes over will be fully impregnated with the aromatic part of the ſubject, and entirely deprive what ſtays behind of all its ſpicy taſte and ſcent; which again confirms, that the oils wherein theſe qualities reſide, are drawn out by ſomething ſimilar to themſelves. The ſimple ſpirit of roſemary is recommended as an excellent remedy in all diſeaſes from a cold cauſe, eſpecially in the vertigo, hyſteric paſſion, apoplexy, *&c.* being taken in the quantity of a dram or two, along with a glaſs of *Spaniſh* wine. 'Tis alſo reputed an admirable coſmetic, by means whereof its inventor, the queen of *Hungary*, is fabled to have preſerved herſelf as beautiful as *Helen* to an extreme old age. This is certain, that it greatly comforts the nervous ſyſtem, when affected or diſorder'd by cold; and ſometimes does good in caſe of contuſions and blackneſs of the fleſh or skin.

## PROCESS LXI.

### *Exhibiting the manner of preparing* compound, medicated, aromatic Spirits.

*The proceſs.*

1. *TAKE of citron-peel, and* China *orange-peel, of each four ounces; lavender-flowers, red roſe, and orange-flowers, of each two ounces; the roots of angelica, and* Florence *orrice, of each one ounce; dry'd mint a handful; cinnamon three ounces; cloves, nutmeg and mace, of each two drams; rectified ſpirit of wine four times the quantity of all the other ingredients; mix them together, and diſtil till the liquor begins to run white; and what comes off before that time will be a rich compound, medicated, aromatic ſpirit.*

*Farther continued, with the virtues and uſes of the production.*

2. If, after the ſpirit is all come over, pure water be pour'd upon the remainder, and the diſtillation be continued with a ſtronger fire, there will be obtain'd a rich kind of compound aromatic water, that may, in a leſs degree, anſwer the like intentions with the compound aromatic ſpirit. And the ſpirit itſelf may be render'd much more noble by two or three cohobations; eſpecially if in the laſt diſtillation, a dram of ſaffron, or ground ambergreaſe tied in a linen rag, be ſuſpended by a ſtring in the neck of the retort, or ſide of the head of the alembic, ſo that the vapor may freely pervade it on every ſide; for by this means the ambergreaſe will yield ſuch an agreeable flavour both to the ſmell and taſte, as not to prove offenſive even to hypochondriacal or hyſterical patients; ſo kindly is it diſſolved by the ſurrounding dew or vapor, and ſo much better than in common digeſtion. And thus an uncommon medicine is obtainable, which might be called by the name of the invigorating

rating cordial. These spirits may be compounded and varied at every one's pleasure, so as to serve in hysteric, apoplectic, cephalic, or almost any other cases, according to the intention of a physician, who knows the specific virtues of the plant he wou'd employ. Thus a cephalic spirit, that shall powerfully raise the drooping patient, may be obtain'd by the distillation of *stæchas* flowers, the *Syrian marum*, rosemary, lavender, rue, marjoram, sage, betony, master-wort, *&c.* in the manner of our present process. By a rectification of these compound aromatic spirits, a true essential oil or quintessence may be obtain'd; tho' it then becomes so subtile and volatile, as scarce to be contain'd in any vessel. For which reason we may usually content ourselves with the spirit that first runs off; as being procurable with less expense, and capable of keeping without loss, and answering the end of the physician.

*Introduction to the chemical history of soap.*

3. We have already seen the effects of spirits upon oils, and what are the productions of the two by combination: the method at first laid down next requires us to shew, what will be the effects of fix'd salts, when united with oils. The principal oils in common use, are those obtain'd by expression, or those procured by distillation; and with both these the mixture of a fix'd alkaline salt will compose a soap. Express'd oils contain a large proportion of acid, which is separated from them by distillation; and therefore, express'd oils easier join themselves with fix'd salts than the essential, or such as are volatile; so that if any oil by expression, as that of olives, for instance, be mix'd with a fix'd alkali, a remarkable agreement may immediately be perceiv'd between them; for in the very instant that they mix they seem to form into a soap: and if they were, for a few hours, to be suspended at the moving sails of a wind-mill, so that they might be violently shook together, they wou'd mix and exhibit a saponaceous body; but at length, after the motion ceases, the saline and watery part will fall to the bottom, and the oil rise to the top. But boiling will permanently reduce them into one uniform body, called by the name of soap. By this means the salt will be so intimately united to the oil, as to become an essential salt, whose nature it is to be join'd with oil. But a light, distill'd volatile oil will not unite, by coction, into a soap with a fix'd salt; because being specifically lighter than water, it exhales in the operation. But in order to make soap with distill'd oils and fix'd alkali, we may use the strongest salt of quick-lime, join'd with pot-ashes, which being exceedingly attractive, has a strange propensity of joining all other bodies with itself, and particularly waters, spirits, acid liquors and oils. The method is to heat this salt, and, whilst it remains in that state, to pour the essential oil thereon; which is then strongly attracted into the salt with a hissing noise. Then the mixture being suffer'd to stand at rest for a few months, the salt and oil will in that time lose their respective natures, and turn to a very sharp soap, as we shall more fully explain hereafter.

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# CHEMICAL HISTORY *of* *SOAPS.*

## PROCESS LXII.

### *Exhibiting the manner of making* Soap, *by boiling express'd oils with* fix'd alkali.

*The process.* 1. *TO one part of good strong quick-lime, set in a glass vessel, add three parts of fix'd vegetable alkali, which is to be gradually moisten'd with water till the lime slakes, or falls asunder.* (2.) *Then boil this mix'd matter in a copper vessel, with a sufficient quantity of water, to make a lixivium, to be filtred and exhaled, after the manner of our twelfth process, till it will support a new-laid egg; at which time it will be fit for our purpose, and is what the soap-boilers call their strongest mother or menstruum; and is indeed so strong, as, when it boils, immediately to consume almost any body that shall fall therein.* (3.) *This strong lixivium being let down with water, or, at first, exhaled only to such a size, as just to suffer a fresh egg to sink in it, is called by the same artists, their weaker mother, or common lixivium.* (4.) *With this weaker lixivium, thoroughly mix an equal quantity of any animal or vegetable oil, gain'd by expression, and boil them together over a soft fire, till at length, with continual stirring and mixing, they begin to unite into one uniform thickish mass; the superfluous water, but not the oil, being exhaled in the operation.* (5.) *Then add three parts of the strongest lixivium abovemention'd, in proportion to the quantity of oil, and continue them boiling, with a gentle heat, and perpetual agitation, till they become of that consistence, as when a little is drop'd upon a cold metalline plate, it appears in the form of an uniform consistent mass, or hard soap, capable of being cut with a knife.*

*Directions relating thereto.* 2. If the soap shou'd happen to be too fat or greasy, so that the oil separates, or appears distinct, 'tis cured by adding more of the strong lixivium, and repeating, or continuing the boiling for a season. But if it proves too sharp, saline or corrosive, which may be known by the taste, and its relenting in the air, after it is cool'd, it requires the addition of more oil, and a farther degree of coction, till at length the due proportion of the ingredients is hit upon, so that neither may predominate, which always affords the most perfect kind of soap. And in this manner are made all the various soaps of *Europe*. But the *Spanish* and *Venetian* soaps are in greatest esteem, those parts abounding with the strongest

ſtrongeſt fix'd alkali, and the beſt oil-olive; whereas in the northern regions, and particularly in *Holland*, we are obliged, for cheapneſs, to make uſe of train-oil, which gives our ſoap a black colour, and a diſagreeable ſcent. The mixture of pure ſalt of tartar and oil, without the aſſiſtance of quick-lime, makes an admirable kind of ſoap.

*Medicinal virtues, and uſes of the productions.*

3. By this proceſs, fix'd alkali is made to unite with any kind of expreſſed oil into a ſimilar maſs that is ſoluble in water, oil, and alcohol, deterging, cleanſing, purifying, attenuating, relaxing, opening, deobſtruent, pectoral, reſolving, edulcorating, ſudorific, diuretic, vulnerary, anodyne; and in ſhort, a kind of univerſal medicine, in ſuch obſtructions as are unattended with a putrefactive, or corroſive oil or alkali, that is, where no inflammatory diſpoſition appears; being enabled, by the fineneſs of its parts, to paſs thro' the whole ſyſtem of veſſels, and unite with all the fluids of the body. This extraordinary medicine may, upon occaſion, be taken after the rate of an ounce in four and twenty hours; being divided into proper doſes for that purpoſe, and ſo uſed at proper intervals. The moſt commodious form of exhibiting it ſeems to be that of pills; tho' it is alſo capable of mixing with a proper vehicle into any liquid form. But as of itſelf 'tis very apt to be nauſeated by the patient, eſpecially when it has long been uſed, it may be proper to tinge it red, and by that means diſguiſe it, with a little gum-lac, cochineal, &c. or conceal it, by the admixture of any other ingredient, ſuitable to the intention of cure. Thus, for inſtance, in the hyſteric diſeaſe, it may be mix'd to advantage with caſtor, oil of amber, or the like. 'Tis a medicine that I frequently make uſe of in my own practice; but then I always take care to prepare it with my own hands, becauſe that which is commonly ſold by the ſoap-boilers is never to be had without lime, which is very apt to corrode the ſtomach and inteſtines; from whence dangerous inflammations may ariſe. I am of opinion, that ſoap, rightly prepared, is one of the moſt pure and excellent medicines we poſſeſs; the numerous virtues whereof may eaſe the phyſician, who is acquainted with them, of a great load of ſimples of much leſs efficacy. We have already obſerved, that it is an almoſt univerſal deobſtruent; or good for all obſtructions ariſing from an exceſs in the diameter of the obſtructing matter above that of the canal thro' which it ought to flow. If we conſider what kind of matter it muſt be that cauſes obſtructions in the body, we ſhall find that ſoap is admirably ſuited to diſſolve its texture, and force it a paſſage with the circulating fluids. Now, it can only be the more groſs and viſcid parts of the fluids themſelves, which, coming together fall into coheſion, and block up the cavity of the veſſels: but all the animal fluids conſiſt of nothing more than water, ſalt, oil and earth; of all which none is more apt to ſtick than the oil, upon account of the ſuperior tenacity of its parts, and its indiſpoſition to diſſolve, like ſalt, in water. And in effect, we ſeldom find that earth is the cauſe of obſtructions in the body; but an unctuous matter that ſometimes ap-

pears like chalk, sometimes like rosin, and sometimes like an oily substance; all which are uncapable of being dissolved by water, and hardly by common salt, but readily yield to fix'd alkali and alcohol; the former whereof, however, might first corrode the vessels of the body before it reached the part, whilst the latter wou'd coagulate the fluids contain'd therein, and by constringing the vessels increase the obstruction, at the time they produce the other effect: so that soap is the only remedy, which can be used with safety and success in the case of obstructions. And this will presently and effectually dissolve away inspissated and harden'd, or pitchy, unctuous matter, unite it to itself, and fit it for expulsion, or a free circulation in the canals again; and all this too in a manner as mild and gentle as it is effectual. Besides this, it surprisingly cures all internal wounds, foul ulcers, *&c.* but, as was hinted above, 'tis as bad as poison where the humors tend to a state of alkaline corruption; and therefore, it is highly mischievous in a phthisis, the stone, fevers, and principally in the plague. Thus it has been remark'd both by the *French*, *English*, and *Germans*, and particularly by *Sylvius*, *Forestus*, and *Diemerbroeck*, that in the time of the plague, almost all the soap-boilers, fullers, and such whose business led them to make use of soap, or even those who put on clean linen, that had been wash'd in soapy water, died of the distemper: whilst those were found to escape, who were in like manner any way concerned with acids.

## PROCESS LXIII.

### *Exhibiting the manner of making* SOAP, *by digesting distill'd oils with* fix'd alkali.

*The process.* 1. *PUT of the strongest fix'd alkali, first thoroughly purged of its earth by solution, filtration and evaporation, into an earthen crucible, and suffer it to flow in a very strong fire, for two or three hours, or till it turns of a blue colour; and whilst it all remains in a fluid state, pour it immediately into an iron mortar made exceeding hot and dry. As soon as ever it ceases to flow, grind it well with a pestle of iron, till, upon cooling gradually, it be reduced to a very dry powder; which, whilst it is yet very hot, is to be poured into a low glass, made flat at the bottom, and wide at the mouth, that has first been throughly heated, and wiped perfectly dry: then immediately pour to the salt such a quantity of clear and well rectified oil of turpentine, or any other essential oil, as may rise about an inch above it; and if the operation be rightly perform'd, the fix'd alkali will now drink in the oil with a hissing noise. Then place the containing vessel in a cellar, that the matter may attract the moisture of the cool air, and in a few days time all the oil will be imbibed by the salt; after which, the matter is to be stirr'd about with a stick several times in a day;*

*day; continuing to pour fresh oil gradually upon it, till the salt be fully saturated; which it will be with about thrice its own quantity thereof. And thus in the space of three or four months, you will have the soap required, which, by way of eminence, is called the soap of philosophers.*

2. Every circumstance mention'd in the process must be carefully observed, otherwise the experiment will not succeed: I myself was obliged to try it more than fifty times before I cou'd make it answer, tho' I exactly follow'd the directions of *Helmont*, *Starkey*, and *Matthew*. But the method here set down has never failed me once. The mortar and glass made use of must be exceeding dry; for the least moisture in any vessel employ'd in the operation wou'd cause all the salt to be thrown about the room with prodigious violence, break the vessels to pieces, and endanger the lives of the spectators: and, if the least drop of water shou'd be conceal'd in the oil of turpentine, or in the salt, no soap cou'd possibly be made thereof. For this reason, the salt, during the operation, must not be suffer'd to cool; because it wou'd then instantly attract the moisture of the air, and by that means prevent the uniting of the oil therewith. In this case, likewise, it wou'd stick so strongly to the sides of the mortar, as might cause great difficulty to separate it again: But the success of this operation depends chiefly upon the agitation of the mixture; by means whereof Dr. *Grew* tells us of a way to prepare this soap in four and twenty hours time. *The cautions it requires.*

3. This preparation goes under different names. It is called the soap of the adept, of *Helmont*, and of *Starkey*, and the corrector of *Matthew*; and is the thing of which they have all so largely treated. If any kind of poison be digested with thrice its own quantity of this soap, the whole becomes of an indifferent, or neutral nature; which is the reason, that in *England* it goes by the name of *Matthew*'s corrector. This *Matthew* was an empyric, who made himself very famous by means hereof: for taking only the surface, or, as it were, the cream of this soap, and mixing it with opium, hellebore, or scammony, he procured a medicine of uncommon virtues; by which, *Starkey* also made himself eminent; the specific virtues of the opium and purging ingredients being supposed over-ruled or destroy'd in his pill, by the alkaline salt. There are some who add both the white and black hellebore, as also liquerise and saffron, as well as opium, in the preparation of these pills; supposing that by this means they become more antidotal: but this occasions them to prove somewhat emetic. And, indeed, the pills publicly sold at *Amsterdam* for *Starkey*'s, being taken over night, will give a vomit the next morning. *Its chemical use.*

4. Upon first digesting, and then committing this soap to distillation in a glass cucurbit, with a gentle fire, it affords a kind of unctuous, volatile salt, sticking to the sides of the glass; so that this process is accounted one of the methods of rendering salt of tartar volatile.

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*Virtues and uses of the production.* 5. The medicinal virtues and uses of this soap are much the same with those of that in the foregoing process; tho' this is considerably less sharp, yet stronger, and of a much more heating and penetrating nature; on which account, it is excellent in all colical, hypochondriacal, and arthritical cases, where any obstructions are to be broke thorough. But, if taken in too large a dose, it stimulates so violently as to cause a distemper perfectly like the ancient *gonorrhœa*; and, therefore, ought to be used with caution. But when a great quantity of it is required, or a great obstruction to be removed, it ought to be well wash'd thro' the passages with large draughts of some emollient decoction; and thus it may be used with safety and success.

## PROCESS LXIV.

### *Exhibiting the manner of uniting the* Soaps *of the preceding* Processes *with* alcohol.

*The process.* 1. *TO a proper quantity of the soap either of the sixty second, or sixty third process, rightly prepared, and well dried, add a triple proportion of pure alcohol; digest them together, for a few days, and they will intimately unite, and compose the lesser elixir of philosophers; in which the three active vegetable principles, essential oil, essential spirit, or alcohol, and fix'd salt are united, without any mixture of the passive, or unactive principles, earth and water.*

*Virtues and uses of the production.* 2. This is by the *Arabians*, *Is. Hollandus*, *Lully*, *Ripley*, and others, called the lesser elixir of philosophers, to distinguish it from the grand one; for making the philosophers stone, which is prepared from metals. It is of this preparation that *Helmont* says, "If you cannot arrive at "the stone of philosophers, search out for the lesser elixir; and be-"come possessed of a medicine capable of curing all diseases." 'Tis indeed a wonderfully efficacious medicine in abundance of cases; but not universal. 'Tis a question, whether it can be with any safety administred in inflammatory diseases. Its virtue is exceeding penetrative, heating and detergent, as may be learnt by its taste; whereby 'tis fitted to pervade the whole body, and dissolve away whatever it finds therein of a glutinous nature. 'Tis much more powerful than soaps alone (especially when prepared by long digestion, which makes a more intimate union of the several ingredients;) as being a volatile, oily, spirituous, vegetable salt, or the joint union of the three active, or most powerful and exalted principles without allay. It is wonderfully heating and deterging; and a small quantity of it, being taken in the morning, with a glass of generous wine, will warm and invigorate the whole frame, and cleanse, and

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open all its canals. In general, it has the same medicinal virtues with the former soaps, only in a much higher degree; being, perhaps, the utmost that vegetables can possibly afford; or the art of chemistry procure from the vegetable kingdom.

3. Having now seen the effects of spirit of wine, alcohol, and oils upon vegetable salts; our next inquiry must be into the action of salts upon salts; which we shall exemplify in the different treatment of tartar.

# CHEMICAL HISTORY *of* *TARTAR.*

## PROCESS LXV.

### *Exhibiting the method of preparing* soluble, *or* tartariz'd Tartar, *otherwise called the* Samech of *Paracelsus.*

1. *TAKE a sufficient quantity of the whitest, purest, and most shining tartar, which is that in the largest lumps; reduce it to an impalpable powder, and boil it over a strong fire, in six or eight times its own quantity of clear rain-water, till it appears to be entirely dissolved; then, as the liquor continues boiling, with great care, and only drop by drop, at due intervals, let fall therein such a quantity of oil of tartar made* per deliquium, *as after having at each affusion excited a most violent ebullition and effervescence with very large bubbles, will at length put a stop to this phænomenon. When now, upon the affusion of a fresh drop of oil of tartar, the ebullition entirely ceases, run the liquor, whilst it is yet violently hot, thro' an hippocras bag; then exhale it to a pellicle, and afterwards suffer it to crystallize in the cold; by which means you will obtain a tartariz'd tartar, that will dissolve in water, or run even by the moisture of the air. Or, the solution itself, without being exhaled, may be kept under the same title for medicinal or chemical uses.* *The process.*

2. 'Tis very remarkable, that the effervescence in this process wou'd not happen, if the alkaline liquor were poured upon crude tartar that was undissolved; the reason whereof seems to be this, that its acid salt in such a state is too intimately united with the other principles to admit thereof. Whence we may venture to draw this general conclusion, that those salts which, whilst they remain solid, or undissolved in the cold, will cause no ebullition with fix'd alkalies, may yet readily do it, and strongly, when applied together in a state of heat and fluidity. The oil of tartar here must be carefully drop'd in so long as it makes any ebullition; and *Observations thereon, with the caution it requires.*

the affuſion thereof ſhou'd immediately be ſtop'd, as ſoon as ever the liquor remains quiet, or free from that diſturbance the drops of the liquid alkali before created; but if you ceaſe the affuſion before this point of time, the compound liquor will prove acid, on account of the predominancy of the crude tartar which is acid: and on the contrary, if more oil of tartar be added, after the ebullition ceaſes, the liquor will become of an alkaline nature, from the over-proportion of the fluid alkali.

*Nature of the preparation and proceſs.*

3. This preparation goes pretty commonly by the name of the *Samech* of *Paracelſus*; but I greatly queſtion, whether it be really that extraordinary medicine, by means whereof he declares he cou'd cure all kinds of wounds, without bringing them to ſuppuration; tho' it muſt be acknowledg'd, that *Helmont* wou'd have his tincture of ſalt of tartar paſs for the *Samech* of *Paracelſus*. There is this extraordinary in the preparation hereof, that an uncommon tranſmutation is here made of the tartar, by its own fix'd ſalt; which alters its nature, and makes it neutral, or neither acid, nor alkali. Tartar is a body very hard of itſelf to diſſolve, and opens not but to a large proportion of boiling water; for cold water will not diſſolve it: 'tis likewiſe ſo ſolid and durable, as to remain, perhaps, for a hundred years, or more, undiſſolved in wine; and yet even this ſtrong body, by the admixture of a little of its own alkaline ſalt, is in the preſent proceſs render'd potable, and ſo ſoluble, as ſcarce to be kept from ſpontaneouſly relenting in a well cloſed glaſs; whence it has alſo obtain'd the name of ſoluble tartar.

*Medicinal virtues, and chemical uſes of the production.*

4. By this mixture of the eſſential ſalt of a vegetable with its own fix'd alkali, an admirable new ſalt is produced, endow'd with laxative, purgative, attenuating, aperitive, ſudorific, diuretic, and antihyſteric virtues. It is an excellent purge in hypochondriacal caſes, and does not leave the body bound up afterwards; for which reaſon 'tis likewiſe ſerviceable in coſtive habits, or ſuch as go to ſtool but ſeldom. It alſo excellently attenuates, and cleanſes away viſcid phlegm; and might, perhaps, be made the baſis of a medicine, to bring away ſand, or the matter that forms the ſtone in the kidneys. 'Tis good in all ſplenetic, and melancholic diſorders, and an extraordinary medicine in the jaundice, tho' grown inveterate; as likewiſe in all ulcerous caſes, attended with foul or purulent matter; being, perhaps, one of the moſt efficacious ſalts afforded by chemiſtry. To anſwer theſe purpoſes, it may ſafely be given alone, being inoffenſive to the taſte, and neither alkaline nor acid, from the quantity of a dram to that of half an ounce, or more; or diſſolved in any proper vehicle. Thus, in caſe of the gravel, for inſtance, it may be drank in the morning, with a large quantity of whey, or other diuretic liquor; and ſo of the reſt. But if it be deſign'd as a cathartic, its doſe may be gradually increaſed, from day to day, till it has its full effect. Beſides its particular medicinal virtues, it is alſo an incomparable

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*menstruum* to dissolve vegetable substances, and especially such as are of a very tenacious or glutinous nature, or otherwise very hard to open: for by means of this preparation, they may be made readily and perfectly to join with an aqueous or spirituous liquor. Thus the tenacious body of myrrh, which is so difficult of solution, being once intimately penetrated with this salt, becomes almost totally soluble in spirit of wine, so as presently to afford a rich and noble tincture: which may seem a kind of mystery to some chemists, who know by experience that fix'd alkali, applied to this gum, binds up the surface thereof, and turns it as it were into a kind of crust, which prevents its yielding a laudable tincture. In short, it seems to be of a more penetrating nature, and dissolves much more readily and expeditiously than other essential salts, which usually require a considerable degree of heat, and a large proportion of water before they will unlock.

## PROCESS LXVI.

### *Exhibiting the manner of preparing* Regenerated TARTAR, *or the* Terra foliata Tartari *of the philosophers, otherwise called the* purging Salt *of* Sennertus.

1. *PUT a proper portion of the strong fix'd alkali of tartar, first made very dry by heat, into a large and clean glass vessel, and, by degrees, pour upon it any quantity of the strongest distill'd vinegar, at pleasure, suppose in all about seven or eight times its own weight, and by shaking the glass, or otherwise, mix them well together. This affusion being made at due intervals, a very small and short-liv'd ebullition will at first appear; but, as more vinegar comes to be poured on the salt, the ebullition will be the greater, last the longer, and still continue increasing both in magnitude and duration, as fresh vinegar is added, and the matter stirr'd about. Continue thus to pour in vinegar at the expiration of each ebullition, till the phenomenon can no longer be excited, even by motion, or shaking the glass, and by this means, after the whole has stood to settle, and deposited its fæces, you will obtain a pure, transparent, scentless liquor, which is neither acid, nor alkaline, but of a sharp, piercing taste peculiar to itself. Filtre the liquor, or decant the clear part, and distill it in a retort almost to dryness; and in the operation the following phenomena will offer.* (1.) *A quantity of pure, and seemingly elementary water will come over, without either scent or taste.* (2.) *The body of the liquor, which was before transparent, or limpid, will begin to change its colour, and continue to do it every moment, so as at length to appear of a blackish brown.* (3.) *A gross, thick, unctuous liquor, in colour between black and red, and of a particular oily, alkaline taste, will remain behind at the bottom, of the retort.* (4.) *To this remainder of the first distillation, again pour, by degrees, a sufficient* *The process.*

*quantity*

*quantity of diſtill'd vinegar; and the phenomena of the ebullition will happen, as before, till the matter be ſaturated ſo as not to bubble, even when briskly ſtirr'd. Then again free the mixture from its feculent part, and commit the pure to diſtillation, as before: and again, inſipid water will riſe, and a thick, unctuous, dark-colour'd liquor be left behind.* (5.) *Continue thus to repeat the proceſs, till the ſpirit of vinegar comes over as ſtrong as it was at firſt poured on; which will be an indication, that the ſalt is thoroughly ſaturated with acid; and, at length, dry the remainder over a gentle fire, to prevent the exhalation of the oil; and there will remain at the bottom a ſalt of a colour between black and red, of a moſt ſharp and piercing nature, very particular in its taſte, ſaponaceous, or of an aperitive, medicinal virtue, and almoſt totally volatile with a conſiderable degree of heat; but, if urged with a ſtrong fire, the major part of it turns to a true inflammable red oil; and when dried in a glaſs veſſel with a more moderate heat, and ſuffer'd to cool, it runs together like a maſs of melted ſilver, and, like talc, becomes ſeparable into thin plates, that are again fuſible by fire. Whence we ſee the reaſon why the ancients called it* Terra foliata Tartari.

*The cautions it requires.*

2. The circumſtances deſcribed in this proceſs are to be carefully obſerved, in order to render it ſucceſsful. Particularly, the fire employ'd in the exhalation muſt be very ſoft and gentle; otherwiſe the oil might eaſily be evaporated, or the whole quantity of ſalt driven away. The fæces depoſited by the mixture of the ſalt and vinegar, are here to be laid aſide, as uſeleſs or detrimental in the operation. Theſe fæces will be found at the bottom of the containing veſſel, tho' the tartar employ'd were ever ſo pure; but from whence they ſhou'd proceed is very hard to ſay. As ſoon as ever the liquor to be diſtill'd comes to be heated, a great ebullition will ariſe; which, however, is not to be aſcribed to the action of the fire, but to the ſalt; and after this, the liquor paſſes ſucceſſively thro' all the degrees of colour, from limpid to dark-brown, or a kind of black. The name of philoſophical earth ſeems given to the laſt production of our proceſs, on account of its being taken for a kind of nutritive matter, uſeful in the preparation of the philoſophers ſtone, which is ſuppoſed to grow from hence, as a plant does out of the ground. It likewiſe goes by the name of the purging ſalt, or tartar of *Sennertus*, becauſe it was by him eſteem'd a very uncommon and extraordinary medicine to cleanſe the body.

*Its chemical uſes.*

3. The proceſs itſelf ſupplies us with a general method of regenerating ſalts from alkali and acid; for it ſucceeds as well in the foſſil, as the vegetable kingdom; with this only difference, that the ſalts thus made from minerals become more fixed than thoſe from vegetables. It is a very fruitful experiment, and furniſhes ſeveral obſervations, which appear as ſo many chemical paradoxes. For, (1.) the ebullition, or, as it may improperly be called, the efferveſcence here made, inſtead of heating,

really increases the coldness of the liquor; and that in proportion to the quantity of motion excited; so that the most violent ebullition shall cause the most intense degree of cold; as is manifest by the thermometer; whilst yet it is generally allowed, that attrition is productive of heat; which in effect is the case in other kinds of effervescence. (2.) The second affusion of the vinegar upon the salt excites a greater ebullition than the first, the third a greater than the second, and so up to the fifth or sixth, or till the point of saturation be gained; which is directly contrary to what happens in the mixture of other salts of an opposite nature; for we commonly find that these operate the more violently upon one another, or cause the greater effervescence, the stronger they are respectively; but in the present case, the weaker the fix'd alkali is made by mixing with the acid liquor, the greater ebullition is excited, till at length the salt has imbibed its fill; which M. *Homberg* remarks for a wonderful phenomenon, as being contrary to the general opinion of chemists, who have given it as a rule, that the stronger the fixed alkali is, the greater will be the ebullition; whereas we learn from our experiment, that an alkali may be too strong to give the appearance of an effervescence with an acid. (3.) The mixture by distillation affords a large proportion of pure water; all that is acid in the composition remaining at the same time fix'd in the alkaline salt: so that what we call by the name of acid spirits have an improper appellation, being in reality no more than acid salts dissolved in water, and that in a very small proportion. It is probable, that all the acid or saline matter which composes vinegar, amounts not to more than a two hundredth part of the whole; as appears by the quantity of water which may be drawn from it by repeated distillation. (4.) Lastly, a large part of *terra foliata* may by heat be reduced to an inflammable oil; as I found to my cost, upon trying to sublime half a pound thereof; and this seems as great a paradox as any of the former. For, how is it possible, one might say, that a fix'd salt, which for the space of many hours has been exposed to a most violent fire, that must needs consume its unctuous part, if it had any, and render it exceedingly dry and lean; and the spirit of vinegar, a liquor allow'd to be the least unctuous of all that are in nature, shou'd, by their mixture, and the treatment of our present process, afford so large a quantity of oil? To this it may be answer'd, that the oil thus obtain'd was latent in the acid salt of the vinegar; or else we must say, that it was produced *de novo*, from a body in which it did not before reside; or lastly, which is somewhat hard to suppose, that it was latent in the fix'd alkali. And that oil may, in a wonderful manner, be concealed in liquors, so as not to be discover'd but by some such method as this, appears probable from hence, that having let some pure spirit of box-wood, in which no oil at all appear'd, stand for the space of two years, it at length deposited a large quantity thereof. And that vinegar itself contains a proportion of oil, appears from its colour, which, tho' diluted

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by the large proportion of water wherein the acid ſalt is diſſolved, will be made more manifeſt, by exhaling its aqueous part, upon which the remaining liquor will become of a full red; and therefore, it muſt neceſſarily participate of oil, becauſe it is to this that all the colours of bodies are owing; for, neither pure ſalt, pure water, nor pure earth have any colour at all. Hence we may obſerve, that ſpirit of vinegar is not a ſimple, but a particular oily acid, unlike to ſpirit of nitre, ſpirit of ſea-ſalt, ſpirit of vitriol, *&c.* all which will afford no oil, when mix'd with the fix'd alkali of tartar. And thus likewiſe *Saccharum Saturni*, which is prepared from vinegar and lead, appears to contain a large quantity of this kind of oil. For, ſcarce any body will pretend, that lead contains a ſulphur ſoluble by vinegar, which being thus converted into oil, may come over in that form upon diſtilling the *Saccharum Saturni*. We therefore, venture to aſſert, that there may be latent oils in acid bodies.

*Its phyſical and medicinal uſes, with the virtues of the productions.*

4. The chemical and philoſophical uſes of this experiment are very conſiderable. It lets us into the method of rendering ſalt of tartar volatile; of preparing an admirable menſtruum for vegetable ſubſtances ſcarce otherwiſe diſſolvable; the opinion of the ancient chemiſts as to *acetum radicatum*; the manner of converting the ſpirit of vinegar into oil; the nature, production, and change of colours, taſtes and odours; fluidity, fixedneſs, volatility, and cold efferveſcence; and laſtly, it ſupplies us with a method of obtaining a compound ſaponaceous ſalt, that is neither acid nor alkaline. A volatile ſalt of tartar has by many been treated as a chemical non-entity; but by our preſent experiment it appears to be no fiction. Thus I remember I once loſt a whole pound of ſalt of tartar, which had been thoroughly drench'd with vinegar; whilſt, with ſome other view, it was too long detain'd in the fire. By means of our preparation, we can readily make a menſtruum capable of diſſolving even myrrh, gum-lac, gum-hedera, or the like glutinous vegetable ſubſtances, with a gentle heat, which is otherwiſe exceeding difficult to effect. The ancients, and particularly the *Arabians*, have wrote a great deal about the *acetum radicatum*. Many are of opinion, that is no more than vinegar ſeveral times drawn over from ſalt of tartar; and at length united with it. But *Zwelfer* is merry with this conceit; being poſitive, that the virtues of both are deſtroy'd by the operation. There is indeed ſome truth in the aſſertion; but *Zwelfer* concludes too haſtily; for the ancients never pretended, that the vinegar was made ſharper by this means; but only, that it was by this union fix'd in its own root, from whence it had its riſe; on which account they gave it the name of radicated vinegar, and ſuppoſed it to be, tho' not more acid or alkaline, yet a much more noble menſtruum, or medicine, than either vinegar or tartar alone. And indeed, its medicinal virtues are exceeding great; for, by its ſaponaceous quality, it opens all the obſtructions of the *viſcera*, more effectually than any other medicine hitherto diſcover'd: and ſchirrous caſes themſelves give way

to

to it. I have myself seen surprizing things perform'd by its means, particularly in scirrhosities, and even in that of the liver, which it gradually dissolves, and wears away with great ease and safety; as acting without acrimony. 'Tis also excellent in disorders of the eyes; being fitted to take off films or specks therein, cleanse the parts, and cure such cataracts as are not grown inveterate. And from this foundation *Mindererus* has a collyrium, prepared with sal-ammoniac and distill'd vinegar, which *Zwelfer* has spoiled, by attempting to correct and improve it. Thus I remember, a chemist was once surprized at my prescribing a mixture of salt of tartar and spirit of vinegar, as if they had been destructive of each other; whilst my intention was to order something that shou'd have a saponaceous and resolving virtue. The changes of colour, observable in the distillation of the liquor, were, doubtless, caused so gradually by the increase of the proportion of the latent oil in the mixture, with respect to the remaining quantity of water; which every moment gave the oil a greater opportunity to manifest itself, upon which all colours depend. Our experiment likewise furnishes us with a remarkable instance, how far fluidity, fixedness, and volatility depend upon mixture, or a mechanical alteration in the parts of the bodies concern'd. Fix'd alkaline and saline bodies require a strong heat to make them flow; but our preparation, consisting of them and vinegar, runs like wax, almost as soon as ever it feels the fire. This great disposition of our preparation to flow with heat, and the resemblance it bears to talc, gave occasion to *Tachenius* to pretend he cou'd dissolve that hard intractable body; and by this artifice he imposed upon several, till at length the cheat was discover'd by the prince of *Holsace*. On the other hand, the acid of the vinegar, which was volatile before, is by the operation so fix'd in the tartar, that nothing but pure water comes over in the distillation; yet when the remaining matter comes to be filtred, crystalliz'd, and dissolv'd again, in order to make a pure white talc, 'twill almost totally evaporate, tho' it before endured a stronger fire. Thus, whilst I once, by this means, endeavour'd to give a whiteness to this salt, I lost almost the whole quantity in the second operation. The observation of the thing was first made by *Bauhin*; and I here think proper to repeat it, because *Sennertus* inadvertently directs us to depurate the salt, I know not how many times, after this method, in order to make it white.

## PROCESS LXVII.

### *Exhibiting the manner of diſſolving* Tartariz'd Tartar, *or making a Tincture thereof, in alcohol, by digeſtion.*

*The proceſs.* 1. *TO a ſufficient quantity of the cryſtals of tartarized tartar, gently dried, reduced to fine powder, and put into a tall glaſs, pour ſo much pure alcohol, prepared with fix'd alkali, as will ſwim the breadth of two fingers above it, and digeſt them together with a heat ſufficient to make them ſimmer; by which means, a ſolution will be made, and a fat, ſpicy flavour'd, gold-colour'd tincture obtain'd; which being poured off, and a freſh parcel of alcohol added to the remains, and the operation repeated, there will, at length, be left nothing but a perfectly white cryſtalline ſalt, adhering to the ſides of the veſſel.*

*Its chemical uſes.* 2. This proceſs ſhews us a method of purifying and whitening ſalts, and freeing them from their oil; namely, by extracting their tinging or unctuous parts with alcohol. And as in digeſtion, the ſoluble tartar here unites with the ſpirit into a ſoftiſh kind of ſubſtance like wax; thoſe are miſtaken who aſſert, that ſalt of tartar cannot be brought into ſuch a form with alcohol.

*Medicinal virtues of the production.* 3. This tincture is of a ſaponaceous, aperitive, and aromatic heating nature; and principally recommended for the cure of freſh wounds; they being touched therewith once in the ſpace of twenty-four hours: when ſo uſed, 'tis ſaid by the elder *Helmont* to prevent their ſuppuration, and heal them without a ſcar.

PRO-

## PROCESS LXVIII.

*Exhibiting the manner of dissolving* Regenerated TARTAR, *or making a tincture thereof, in alcohol.*

1. *TO a proper quantity of regenerated tartar, carefully dry'd before a gentle fire, pour as much pure alcohol as will cover it to the breadth of two or three fingers; then digest them together with a soft heat, and by that means there will be made a tincture, or almost total solution of the salt, in the form of a red, unctuous, saponaceous, acid and spirituous liquor; only a very small quantity of fæces remaining at the bottom.* *The process.*

2. This process gives us another method of intimately uniting volatile, fermented, acid salts, with the fix'd alkaline ones, by the interposition of a pure vegetable sulphur, so as to form a compound, volatile, oily, and saline spirit; which also, as well as the production of the sixty fourth process, is therefore call'd the *lesser medicated elixir of philosophers*; the difference only consisting in here substituting acid for oil. *Its chemical use.*

3. The tincture of regenerated tartar is a noble medicine in case of obstructions; and may at all times be exhibited with the utmost safety, unless the disorder be attended with an inflammation, or the constitution be naturally hot. It powerfully resolves all scirrhous and strumous swellings, or indurations of the glands; and may be of service in the gout and dropsy, provided the *viscera* are not corrupted. It is of an exceeding penetrative, yet inoffensive nature; acting with the greatest gentleness and ease, either as a sudorific, diuretic or cathartic; as it shall be determin'd by the virtue of the vehicle, or medicine, along with which it is given. It may be taken in the quantity of a dram for a dose, in the same manner as was formerly mention'd of the salt of *Tachenius*. The only inconvenience that attends it is its costliness; which renders it less generally useful. Instead of it may be employ'd, for those of narrow circumstances, the filtred solution of pot-ashes, made by heat, with twenty times its own quantity of vinegar; which is an admirable medicine, being used, by way of fomentation, in scrophulous and scirrhous tumors. But care must be had in the preparation fully to saturate the salt with acid, otherwise it will excoriate the part to which it comes to be applied. *Its medicinal use.*

## PROCESS LXIX.

### *Exhibiting the manner of preparing* Harvey's Tincture of Salt of TARTAR, *with rectify'd spirit of wine.*

*The process.*

1. UPON *a proper portion of salt of tartar, calcined to a perfect fix'd alkali, and reduc'd, whilst thorowly dry, to a powder, and put into a tall glass, pour twelve times its quantity of spirit of wine, that has been only once rectify'd; and boil them together, with a gentle heat, for the space of thirty six hours: by this means there will be obtain'd a deep red, or black colour'd tincture, of a penetrating, alkaline, and lixivious nature; which, by a gentle inclination of the vessel, is, when cold, to be poured off, or otherwise separated, as by the filtre, from the imperfectly dissolv'd salt, that, in a fluid form, will remain behind.*

*By whom invented.*

2. My method of preparing this tincture, is in a very tall glass, with the heat of my wooden digesting-furnace; which does not exceed that of the body of a man in health. It is call'd by the name of *Harvey*, only because that learned physician of *London* heartily recommended and successfully prescrib'd it; being originally the invention of *Paracelsus*, and one of his principal secrets.

*Its medicinal uses.*

3. This tincture is accounted a noble detergent medicine; the spirit of wine actually dissolving a considerable part of the fix'd alkali. It is useful chiefly in such habits as abound with acid humors and viscid phlegm; or in those cases where obstructions in the *viscera* are to be remov'd, or the thick offending juices to be forc'd thro' the kidneys, or thrown off in sweat, or insensible perspiration. Thus it is successfully used by hypochondriacal, leucophlegmatic and dropsical persons; in the green-sickness, scirrhous tumors, the scurvy, and all those distempers which proceed from a cold, acid, phlegmy or depauperated blood, that blocks up the canals. For the same reason it admirably deterges old ulcers, whether external or internal, even those of the lungs; provokes the appetite, strengthens the stomach and intestines, helps to discharge their fæces; and in short, it may be made serviceable in every case that is not attended with an inflammatory disposition; being determin'd and fitted for the purpose by the particular vehicle, or other ingredients, with which it is given. It may be taken in the quantity of two or three drams for a dose, twice or thrice a day. Dr. *Harvey* orders a spoonful of it at a time, in the dropsy, scurvy, and phthisic, if the patient be weak, and the juices acid, mix'd along with some soft sort of wine, hydromel, or mead; and the dose to be repeated three or four times in a day: by which means he recover'd abundance of hydropical patients; the medicine bringing away an incredible quantity of urine. It might likewise be mix'd, for taking, with honey, or any opening syrup, not

so acid as to cause an ebullition therewith, as the syrup of the five opening roots, or the like; which is a convenient manner of exhibiting it in dropsical cases. And when thus repeated in small doses, as that of a dram or two, several times a day, it wonderfully improves a vapid blood, dissolves away the mucus that obstructs the vessels, and gives warmth and vigor to the whole body.

## PROCESS LXX.

### *Exhibiting the manner of preparing* Helmont's Tincture of Salt of TARTAR, *with alcohol.*

1. TAKE *any quantity of white, crude tartar, in the lump, wrap it up in thick cap-paper, first made a little moist, and lay the whole upon an iron-plate, plac'd upon a stratum of live coals; then build up a clear fire all around the plate, and gradually heighten it to the strongest degree; by which means the kindled matter will at length be made to flow, and unite into one white, spongy mass; which being detain'd, for the space of half an hour, in the same degree of heat, is call'd by the name of* calcin'd tartar. (2.) *When the coals below the plate are consum'd to ashes, take away the surrounding fire, and, with a pair of tongs, remove the calcin'd tartar, or hard saline mass, which will be now reduc'd to little more than a fourth of its original weight, and dissolve it in hot water; filtre the solution, and exhale it in an iron-vessel, over a strong fire, towards the end of the operation; keeping it continually stirring with an iron spatula, or ladle, till there remains nothing behind but a very dry and snow-white salt, call'd by* Helmont *the principal of fix'd alkalies, but vulgarly the common salt of tartar depurated* *. (3.) *With this salt of tartar fill a close, strong crucible, and, with the gradual heat of a wind-furnace, keep it continually flowing for the space of six or eight hours, or till it becomes of a brown colour; then presently pour it out into a metalline mortar, that has first been made exceeding hot and dry; and thus, with a heated metalline pestle, reduce it into as fine a powder as is possible.* (4.) *Put this powder, whilst it is yet very dry and hot, into a tall, well heated and well dry'd glass, with a slender neck, and pour upon it pure heated alcohol enough to float five or six fingers breadth above it; the alcohol, upon this, will be drank in by the salt, with such a kind of noise as that made by the slaking of lime with water. Then boil them together over a soft fire, for the space of thirty-six hours, and by this means a deep red tincture will be exracted from the fix'd salt, of a perfect balsamic taste; which, when cold, is* Helmont's Tincture of salt of Tartar. *The process.*

* This is the common salt of tartar of the shops.

*Cautions to be observed in it.* 2. There are many eminent chemists, and among the rest the famous *de Maats*, *le Mort*, &c. who deny the possibility of extracting a tincture from salt of tartar, with pure alcohol; but they are certainly mistaken, and fail'd in the experiment only for want of attending to all the circumstances of it, without which it will never succeed. Thus if the salt be not exquisitely dry, or the least aqueous mixture be left in any of the vessels, or the alcohol made use of, the spirit will thereby be kept from acting upon the salt, and so no tincture will be produc'd. Thus it is found impossible permanently to mix pure alcohol with oil of tartar; the water acquired by the salt in running *per deliquium*, preventing the entrance of the alcohol into it. The same will likewise happen if the fix'd alkali remains so long in the mortar as to attract the moisture of the air; which it does so strongly as scarce to be kept a few minutes cold without relenting. 'Tis observable in calcining the tartar, that its spirit goes off into the air, together with its oily acid of the first order; whilst a considerable part of that of the second order remains with the other spirit in the mass, so as to give a high colour to the limpid alcohol. The tartar may likewise be calcin'd in an open fire, without the assistance of a metalline plate, by throwing it upon live coals, and covering it over with others; but then it will melt and run among the ashes: from which, however, it may again be freed by means of a sieve. The lixivium, in the second step of the process, is to be kept stirring towards the end of the exhalation, in order to prevent the salt from sticking to the bottom of the vessel, and preserve its whiteness. In the third step of our process, the salt in the cover'd crucible ought to be detain'd for a considerable time in the fire, to fit it for the purpose; and indeed the longer it is here kept close, the better it will be. During its detention, it will pass thro' several degrees of colour, provided no smoke or other foreign body comes at it, till at length it arrives either at a greenish blue, or a brown. The degrees of fire ought here to be carefully regulated at first, in order to prevent the cracking of the crucible, and to keep the salt in a proper fluor, till it be reduc'd to the due colour; which may be known by dipping the end of a dry iron rod into the crucible, as it stands upon a tile in the fire, and bringing away what salt shall stick thereto. Thro' the whole operation, great care must be had that not the least drop of water touch the melted salt; for this might make the crucible, glass, or mortar, fly into a thousand pieces, and throw the salt about the room in a desperate manner. Instead of pouring the heated alcohol upon the salt of tartar, it may, perhaps, be more commodious to throw the heated salt into the hot alcohol, contain'd in a proper vessel of glass set ready at hand for the purpose.

*Its chemical uses.* 3. This tincture, we see, is a most subtile oil, or sulphur, united, by means of fire, to the most subtile part of a fix'd alkali; whence it is in reality a very subtile and attenuated kind of soap. That it is an actual tincture of the salt, appears from the colour which the alcohol acquires

upon

upon it; tho *de Maats* will needs have this to be no proof; pretending that the ſpirit it ſelf would by digeſtion at length become of this colour, without the aſſiſtance of the ſalt. But experience ſhews, that pure alcohol will remain for a ſeries of years without at all changing its colour by being digeſted *per ſe.* Beſides, as the taſte and ſmell of the tincture confirm it gain'd from the ſalt of tartar; ſo likewiſe does the touch: for it is ſaponaceous, and detergent to the hands. And further, by diſtillation it actually leaves a quantity of fix'd ſalt of tartar behind it; and even what comes over will exerciſe hoſtility, or make an ebullition, with acids. So likewiſe, if the tincture be ſuffer'd to reſt for ſome years, it will depoſite a true oily ſalt of tartar. All which are arguments beyond exception, that this preparation is an actual tincture of a fix'd alkali. Whence we are furniſh'd with an example, that the ſtrongeſt and moſt fix'd alkali may be united with alcohol, and by that means render'd volatile: a ſecret of which *Paracelſus* and *Helmont* have ſo largely diſcourſed. And thus the remaining part of the ſalt, left undiſſolv'd by the ſpirit, after a long digeſtion, and the extraction of the tincture, loſes a great deal of its alkaline acrimony; and, contrary to the nature of ſalt of tartar, will flow by a gentle fire, like wax, ſo that at length it becomes an incomparable ſoap; for no alkali is more ſubtile than that of tartar, nor oil more pure and fine than that of alcohol. This was originally the obſervation of Mr. *Boyle*, who gives a great commendation of the ſalt by ſuch means procur'd; tho other chemiſts have commonly thrown it away as uſeleſs. And the longer the ſpirit is digeſted upon it, the more ſaponaceous it becomes; till at length, it will not make an ebullition with acids.

*The medicinal and chemical uſes of the production.*

4. This tincture is an admirable attenuating, aperitive, alkaline, ſaponaceous, and oily medicine, as well as menſtruum, of the ſame virtues with that of the preceding proceſs, tho not capable of being, like that, exhibited alone, for fear of excoriating the part along which it paſſes. For this reaſon it ought, when taken, to be diluted with water, which renders it much the ſame thing as *Harvey*'s tincture of ſalt of tartar; which in this caſe might commodiouſly be ſubſtituted for it. As a menſtruum 'tis wonderfully ſerviceable in extracting the tinctures of ſtubborn, gummy, or ſulphureous, vegetable bodies, ſuch as myrrh, gum-lac, amber, &c. which, with the help of digeſtion, are excellently diſſolv'd thereby. But being ſo laborious and chargeable to procure, *Harvey*'s tincture is generally allow'd the preference for medicinal uſes.

*Introduction to the Hiſtory of ELIXIRS.*

5. We have now ſeen the fix'd alkali of vegetables united with water, two kinds of oil, expreſs'd and diſtill'd, with vinegar, common ſpirit of wine, and pure alcohol; whence we may perceive that it is convertible into almoſt any form, at pleaſure. And this brings us to the preparation of elixirs, as the next link of our chain; they being no more than ſtrong tinctures, in which the ingredients employ'd are almoſt totally diſſolv'd. And theſe we ſhall ſhew how to make, with the various productions of our former proceſſes; as particularly with ſpirit of vinegar,

fix'd alkali and diſtill'd waters, alcohol and fix'd alkali, tartariz'd tartar and ſpirit of wine, regenerated tartar, *&c.*

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## Chemical History *of ELIXIRS.*

### PROCESS LXXI.

*Exhibiting the manner of preparing* ELIXIRS *with diſtill'd vinegar, by an example in* Elixir Proprietatis.

*The proceſs.* 1. *TO an equal proportion of myrrh and aloes, reduc'd to fine powder, and half the quantity of either of fine ſaffron, pour twelve times their own weight of good ſpirit of vinegar, and let them ſimmer gently together in a tall glaſs, for the ſpace of twenty-four hours; then, when the whole is cold, pour off the clear tincture, or let it ſtand upon the undiſſolv'd part of the ingredients, in a cloſe veſſel, under the name of* elixir proprietatis.

*Cautions to be obſerved in it.* 2. Only half the quantity of ſaffron, in proportion to the two other ingredients, is here order'd, that the medicine may come the cheaper; and indeed the reſt may well enough be ſpared, if all the ingredients are at the ſame time committed to the menſtruum; which being, by means of the operation, ſufficiently ſaturated with the myrrh and aloes, cannot take out the virtue of ſo large a proportion of ſaffron. And for this reaſon, when the medicine is deſign'd rather as a cordial than a balſamic laxative, the ſaffron is firſt put to infuſe, in an equal quantity with the other ingredients, for ſome time before the latter are added. Inſtead of making the ingredients boil in the menſtruum, it might ſuffice to keep them longer together, as for the ſpace of ſeveral days, in a moderate heat of digeſtion: and they may, when cold, be likewiſe ſuffer'd to ſtand together; becauſe by this means the menſtruum will be the more impregnated with the ſoluble parts of the ingredients.

*Its origin, and hiſtory.* 3. *Paracelſus* was the man who firſt reduced theſe three ingredients into the form of a liquor; to which he gave the name of *elixir proprietatis.* The word elixir is of *Arabic* derivation, and originally ſignifies a great aſſiſtant; to which in the preſent caſe he added the word *proprietatis,* as believing, according to what he tells us in his book upon long life, that this medicine was peculiarly adapted to preſerve the native balſam of the human body, and prolong its duration beyond the age of *Methuſalem:* but no body before *Helmont* pretended to ſay wherein its peculiar virtue or power of doing this conſiſted. *Helmont* tells us, that three things are requir'd in order to the attainment of long life, *viz.* cleanſing

ing the body of what is fæculent in it, preserving it from putrefaction, and raising the spirits thereof; all which he says are effected by the ingredients of this elixir; the aloes purging off whatever might obstruct the vital functions, the myrrh defending the body from corruption, and the saffron powerfully raising the spirits, and enlivening the heart. The *Greek* writers observe, that the *Egyptians* were possess'd of some certain secret way of embalming, or preserving dead bodies from corruption, even for a thousand years; and this, according to *Herodotus* and *Diodorus Siculus*, they effected by means of aloes, myrrh, and saffron. *Paracelsus* having learnt so much, presently concluded, that men might be made immortal, if a way could be discover'd of preserving the humors of their bodies from putrefaction; not considering that distempers may prove mortal, tho they give no signs of putrefaction in the body: and this notion prevail'd so strongly with him, that he for ever after imagin'd the preservation of health and continuance of life might be obtain'd by taking medicines that opposed corruption in the body. *Helmont* likewise gave a little into the same opinion. And no wonder if two such great men should be mistaken in this affair; considering they were unacquainted with the circulation of the animal fluids. The authority of these famous chemists brought a great many more into the same sentiment; so that at length there were some who pretended, that as the grand elixir is the remedy for all impure metals, gold alone excepted, as being of it self sufficiently pure; so the *elixir proprietatis* of *Paracelsus*, or myrrh, aloes and saffron brought into one homogeneous liquor, was the cure of all diseases, and particularly adapted to the preservation of life. We must indeed allow, that scarce any known medicine is more friendly to the human body than this elixir; and *Paracelsus* tells us, he was induced by *Christian* charity to publish the secret of its preparation for the benefit of mankind. He took equal quantities of these ingredients, and digested them together in cinnamon water, or spirit of wine impregnated with the essential oil of cinnamon, for the space of three months, in a glass hermetically seal'd, before he pour'd off the clear liquor from the remaining fæces. But *Rufus Ephesius* was the first who employ'd a mixture of the same ingredients, in the form of pills, as an antidote against the plague; which he did with such success as increas'd *Paracelsus*'s opinion of their virtues. And to say the truth, these purging pills of *Rufus* are excellent in all distempers which proceed from a cold cause, or require the heat of the body to be augmented in order to their cure; but they have this fault belonging to them, that they render such as take them subject to the piles, on account of the tenacity of the aloes they contain; which faculty therefore requires to be corrected by some proper dissolvent; as was afterwards done by *Paracelsus*. But *Crollius*, in his *Basilica Chemia*, denies that this elixir can be prepared in *Paracelsus*'s manner; and with some justice on his side: but himself is likewise mistaken in expecting to amend the thing by digesting the ingredients with oil of sulphur *per campanam*;

*campanam* ; tho he firſt moiſtens them with ſpirit of wine : for as ſoon as ever that ſharp liquor is pour'd upon the ingredients, the myrrh and aloes are thereby burnt to a kind of coal ; ſo that the addition of freſh ſpirit of wine cannot afterwards extract a twentieth part of their virtue, and only a ſmall portion of their roſin ; leaving the other parts untouch'd, in the form of a cruſty matter at the bottom of the glaſs. *Helmont*, therefore, adviſes to digeſt them without any menſtruum at all, till they are brought into a kind of oil ; and afterwards to pour the ſpirit of cinnamon thereon : but neither will this method anſwer the end propoſed ; for thus alſo the ingredients will be burnt. My opinion is, that if we would make an univerſal medicine of this elixir, we muſt vary the menſtruum according to the intention of the phyſician ; and thus, in caſes where a peccant alkali predominates, I know no better liquor to prepare this elixir with than the ſpirit of vinegar ; which is an unctuous acid, that agrees very well with the human body, and diſſolves all the ingredients as perfectly as any other menſtruum : for which reaſon this preparation of the elixir may commodiouſly be uſed inſtead of that made with oil of ſulphur *per campanam*.

*Medicinal virtues of the production.*

4. This elixir is a medicine of great virtues, and capable of entring all the veſſels of the body ; but as prepared with vinegar, 'tis thereby principally determin'd to ſuch diſtempers as proceed from an alkaline cauſe, tending to introduce a corruption of the humors ; or where the body abounds with a viſcous, thick, corrupting bile, or viſcid phlegm. It alſo diſcharges the inteſtines of their load, gives an appetite, and admirably provokes both ſweat and urine. In the alkaline ſpecies of the ſcurvy, to which ſuch as uſe the ſea are particularly ſubject, 'tis preferable to any medicine I know ; as admirably preſerving or repairing the corrupted gums, and other ſcorbutic diſorders of the mouth, if apply'd hot thereto. It likewiſe has the virtue of deſtroying worms in the body ; and being taken in the quantity of half an ounce, with a draught of warm water, or ſmall beer, it proves an excellent ſudorific in the plague. But in the putrid ſcurvy, and other common caſes, no more than two drams need be given for a doſe, to be repeated occaſionally ; and in ſuch a quantity as this, or, if there be occaſion, a greater, it proves a mild and ſafe cathartic, proper in continual fevers ; as being a fine acid, aromatic and oily ſolutive medicine. But when a burning fever is, as it frequently happens, attended with an alkaline corruption, and great viſcidity of the humors, this acid and deobſtruent elixir is truly admirable. 'Tis alſo a powerful medicine, when externally us'd, in putting a ſtop to a gangreen ; for being apply'd hot to the part, with linen rags, it will ſoon procure a ſuppuration : and theſe are virtues, to give it its juſt character, of which this medicine is really poſſeſs'd.

## PROCESS LXXII.

*Exhibiting the manner of preparing* ELIXIRS *with fix'd alkali and distill'd waters, by an example in* Elixir Proprietatis.

1. TO *the ingredients mention'd in the preceding process, pour such a quantity of oil of tartar* per deliquium, *as will make them into a mass of the consistence of thick panada; and digest them together, in a tall glass, with a gentle heat, for the space of four and twenty hours; then add about twelve times their quantity of any distill'd aromatic water, at pleasure; for instance, that of cloves or mint; or so much as will reach the breadth of three fingers above the ingredients; and boil them together for twenty four hours longer, and the elixir required will be obtained.* *The process.*

2. It might perhaps be a better method, tho more tedious, of preparing this elixir, by first digesting the ingredients with the oil of tartar, in a flat-bottom'd vessel with low sides; then boiling the matter over a gentle fire, till it becomes almost dry; and afterwards exposing it to the moist air of a cellar, that it may again run *per deliquium*, and again be exhaled and dry'd as before; and lastly digested with the distill'd water: for by this means there would be made a total solution of the ingredients, excepting only a few fæces. If instead of the distill'd water in this process, there be used spirit of wine once rectify'd, a more heating and sudorific, but less purgative elixir will be obtain'd, or, as it were, a balsam prepared with *Harvey*'s tincture of salt of tartar: for the liquor in this case will be thick, almost like oil; as containing the gummy and gross resinous parts of the ingredients; whereas pure alcohol would draw out only the finer. *Other ways of performing it.*

3. The virtues of this tincture, allowing for the difference of the menstruum, are the same with those of the elixir of the preceding process. 'Tis subject to one inconvenience, that of turning mouldy by keeping; otherwise it might be made and prescrib'd to as good advantage as that; and in all the same diseases, provided they proceed from a contrary cause; or whenever austere, acid, or cold phlegmatic humors predominate in the body. It is aperitive, attenuating, dissolving, stimulating, cathartic, diuretic, sudorific, vulnerary, *&c.* But where the humors of the body are already dissolv'd down, or their texture broken, as in the plague, malignant fevers, *&c.* it ought never to be given; for in these cases it is highly pernicious. But in such obstructions of the menstrual flux as happen in a phlegmy habit, oppressed with a peccant acid, it is of very great service; being taken, in a proper dose, for a considerable time together. In short, this elixir is convertible into a medicine of almost any virtues, according as it shall be determin'd by the menstruum. *The medicinal uses of the preparation.*

ſtruum. Thus it may be made to act entirely as a ſudorific, purgative, diuretic, *&c.* by preparing it with ſuitable diſtill'd waters of certain vegetables, or by the admixture of other medicines, reſpectively endow'd with thoſe virtues.

## PROCESS LXXIII.

### *Exhibiting the manner of preparing* ELIXIRS *with alcohol and fix'd alkali, by an example in* Elixir Proprietatis.

*The proceſs.*

1. *Reduce an equal quantity of myrrh and aloes to fine powder, and pour upon them twice their own weight of oil of tartar* per deliquium; *then digeſt them in a low, broad-bottom'd veſſel, for four and twenty hours, with a gentle heat; at length increaſing the fire, till the matter becomes nearly dry: then let it run again by the moiſture of the air; and after that digeſt and exhale it again to a dry maſs; which being put into a tall glaſs, add thereto half as much ſaffron as was taken either of myrrh or aloes, and pour to them ſuch a quantity of pure alcohol as will riſe the breadth of three or four fingers above their upper ſurface; then boil them gently all together, for four and twenty hours: and laſtly, when the glaſs is cold, pour off the clear tincture from the ingredients. And thus the elixir will be made, tho the ingredients are not all diſſolv'd, or totally depriv'd of their virtue.*

*Its chemical and medicinal uſes.*

2. We may learn from this experiment, that alcohol is not always the beſt menſtruum with which to extract tinctures, or take up the virtues of ingredients; for here the elixir is much thinner, and more diluted in its colour, than in the preceding proceſs, when a ſpirit let down with a proportion of water was employ'd; or than it would be if drawn with ſpirit of wine that hath been but once rectify'd. This elixir, however, is of an exceedingly penetrative, aperitive, reſolving, attenuating, and ſtimulating nature, but leſs purgative and more heating than thoſe before deſcrib'd. It is alſo ſudorific, diuretic, and proper in thoſe diſeaſes which require balſamic alkalies for their cure; as the muriatic ſcurvy, the green-ſickneſs, univerſal dropſy, *&c.* It may be conveniently exhibited, from the quantity of half a dram to half an ounce for a doſe, along with ſome proper ſyrup. It is alſo generally recommended for the cure of external ulcers, tho of long ſtanding, without the aſſiſtance of plaiſters; eſpecially when a mucous humor, or ichor, diſtills from the ruptured lymphatics: but as it deterges powerfully, when the ulcer is once thorowly cleanſed the medicine ſhould afterwards be mixed with water; and by this means it may be made into a cicatrizing and conſolidating, as it is of it ſelf an eſcharotic and detergent remedy: ſo that even fiſtula's may be healed up by it; if it can but, by the management of the dreſſings, be apply'd to the bottom thereof. In the ſame manner, it is of excellent uſe in caſe of carious bones; as ſerving to ſtop the growing miſchief, and preſerve them from farther putrefaction.

Internal purulent ulcers are likewise cured by the internal use of this medicine: for which reason, 'tis highly valued both by chirurgeons and physicians. 'Tis also possess'd of an embalming virtue, like the balsam of the antients; whence it preserves dead bodies from corruption, by strongly binding up the solids, and thickening the fluids thereof: so that for practical uses we could be without almost any medicine rather than this.

## PROCESS LXXIV.

*Exhibiting the manner of preparing* ELIXIRS *with rectified spirit of wine and soluble tartar, by an example in* Elixir Proprietatis.

1. *IF instead of oil of tartar, in the preceding process, the liquor of tartariz'd tartar be substituted, and the process be carry'd on exactly in the same manner as is there describ'd, but with rectified spirit of wine, a much thicker elixir will be procured, of a neutral nature as to acid and alkali, and more impregnated than the former with the virtues of the ingredients, which here are almost entirely dissolv'd.* *The process.*

2. The myrrh and aloes, by being digested, dry'd and treated with the soluble tartar, as the process requires, will be totally converted with it into one saponaceous mass; almost the whole whereof will be readily taken up by the spirit of wine, and suffer no alteration in its virtue from the mixture either of acids or alkalies: for which reason, this cannot but be the best method hitherto exhibited of making the *elixir proprietatis*; which, thus prepared, may be safely given in doubtful distempers, where we are not certain whether an alkali or an acid presides in the body; without observing any particular cautions which in other cases must of necessity be regarded. It is principally useful in hypochondriacal cases, and where the bile is so thick as to require diluting, or to have its texture open'd. But if, instead of the spirit of wine, any distill'd water, suitable to the intention of cure, be made choice of for the menstruum in this process, we may readily obtain a most noble elixir, to be given in any distemper with the utmost safety. *Excellence of the preparation.*

## PROCESS LXXV.

*Exhibiting the manner of preparing* ELIXIRS *with alcohol and regenerated tartar, by an example in* Elixir Proprietatis.

*The process.* 1. *TO equal quantities of myrrh and aloes, reduced to fine powder, pour as much liquor of regenerated tartar as will serve to reduce them into a thickish fluid mass; which is to be digested a while, with a gentle heat, the matter being kept continually stirring, till it appears entirely dissolved: then put to it a quantity of saffron, reduc'd to fine powder, equal to that either of the myrrh or aloes, and three or four times as much alcohol as there was liquor of regenerated tartar: then boil them softly together for half an hour; by which means there will be procured a noble, and thick balsamic elixir, containing almost the whole substance of the ingredients; a very small proportion of fæces remaining behind, after the clear liquor is decanted.*

*Its excellence.* 2. This process shews us a short, cheap, and easy method of making the most noble and efficacious elixirs that can be hoped for in medicine; especially, if instead of alcohol we use only spirit of wine; as might be done to good advantage: for in this elixir, the fix'd salt of tartar being render'd volatile, and set loose, seems to exert those virtues and powers which *Helmont* so amply extols in volatiliz'd salt of tartar, both upon the human body as a medicine, and several stubborn and untractable substances as a menstruum. And in effect it is a most penetrative, saponaceous, and balsamic liquor, not to be exceeded by any thing of the same nature.

3. It is to be observ'd, that all these processes for the preparation of *elixir proprietatis* are no less general than the rest, tho they may seem particular, and limited but to three ingredients; for if other gums were used instead of myrrh and aloes, the processes would hold equally good.

CHE-

# Chemical History *of AMBER.*

## PROCESS LXXVI.

*Exhibiting the manner of analyzing bodies, in order to discover of what kingdom they are, by an example in that controverted subject* AMBER.

1. *FILL two thirds of a coated retort with amber, brought into small lumps by the mortar; then fill it up to the neck with clean dry sand; fit it with a large receiver, that lying almost horizontal, may let the vapors come over freely; and lute the juncture. The retort being placed in a sand-furnace, let the fire at first be made only so strong as to cause a dew upon the receiver, and make the liquor just begin to drop: continue this mild degree of heat till all the aqueous, spirituous and acid liquor is come over, or till it will cause no more to rise.* (2.) *Then increase the fire till another liquor begins to rise, or till white fumes appear in the glass, and the receiver grows warm. Carefully keep up this degree of heat as long as any liquor will run therewith; otherwise the receiver, how large soever it be, will crack. By this means there will be brought over a fine, transparent, ponderous, yellow oil, of a penetrating nature, almost like oil of petre. And when this has almost ceas'd to run, a white, transparent, perfectly acid, and almost solid salt, will fix it self in the neck of the retort, and sides of the receiver; being the only thing of this kind in nature, and capable of flowing at the fire, dissolving in water*, and shooting into the form of a firm white glebe.* (3.) *The fire being now again augmented, there comes over a very thick kind of oil, of the nature of petroleum, and lighter than the former; but if a fire suppression be made, it becomes heavier than that; nothing but a gross, viscid, black, pitchy matter, like colophony, remaining behind at the bottom of the retort; and this likewise, by continuing the operation, may almost totally be brought over in the form of that thick gross oil, which, when cold and dried, appears like bitumen†.* *The process.*

* This salt is likewise said to be the only one that is readily dissolvable in spirit of wine; which is therefore commonly esteem'd the criterion of its purity. The price hereof being large, 'tis a great temptation for the chemical dealers to adulterate it with cheaper salts; *ol. succini, sal ammoniac. sal Ebisham.* &c.

† The process for analyzing amber is variously describ'd by chemical authors; some, as *Glaser*, *Charas*, *le Febure*, *le Mort*, *Vigani*, *Lemery*, &c. advising the subject to be distill'd with, and others without an addition; these with, and those without pulverization; some with, and others without luting the receiver, rectifying the spirit, oil, salt, &c. One is for a sand-heat, another for a naked fire; one for a large yellow amber, another for a small and white one; with other variations too tedious to enumerate. It may, with a tolerable degree of skill, be managed to advantage in the manner here described, with very little trouble.

2. By

*How improved.* 2. By rectifying, or distilling over again, the several parcels of liquid afforded in this operation, they may be separated and obtained more pure than they rise at first; so that the water and spirit, or acid liquor, now rise distinct, the odd kind of salt shoots afresh to the sides of the glass, and all of them appear possess'd of a penetrating balsamic virtue.

*Its uses in chemistry and natural philosophy.* 3. We learn from this experiment, (1.) That acid salts, as well as the alkaline, may exist in the solid form of crystal. (2.) That the hard, dry, and almost glassy body of amber, is resolvable into water, spirit, salt and oil. And, (3.) That this strange substance, tho it belongs to the vegetable, greatly resembles a subject of the mineral kingdom; for amber dissolves in alcohol but not in water, melts at the fire, and is inflammable: so that it might very well pass for a species of sulphur, or bitumen. 'Tis indeed a wonderful substance, whose origin is not yet sufficiently known *, tho most probably a vegetable; as we may fairly conjecture from our present process: since it may be resolved into the same parts with vegetables; *viz.* water, spirit, salt, and oil; and possibly not unlike the camphire of *Asia*, which, being the concreted oil of the aromatic plants of that country, affords us an example that oils elaborated by a great degree of heat may appear in a crystalline form.

*Its uses in medicine.* 4. The acid volatile salt obtain'd in our analysis, being purify'd by sublimation, and separated from its oil, becomes very white, and affords us one of the best diuretics hitherto known in medicine. And the fine yellow oil, by rectification †, becomes a noble antihysteric and emmenagogic, no less subtile than *petroleum.*

* That amber is really no more than a concreted resinous juice; which originally proceeds from vegetables, is made very probable by the learned naturalist *Pliny*, and confirm'd by *F. Camelli*, who himself has seen large pieces of it brought down from certain mountains in the *Indies*; and the like, he says, is found in a fluid form in several of the *Eastern* provinces, where it is called by different names: See *Philosoph. Transact.* N° 290. *Plin. Nat. Hist.* lib. xxxvii. cap. 3.

† This is the best sort of oil of amber, commonly sold in the shops.

CHE-

# Chemical History *of VEGETABLE PUTREFACTION.*

## PROCESS LXXVII.

*Exhibiting the phænomena of* Vegetable Putrefaction, *with its various effects, or the manner of converting vegetable into animal substances.*

1. *THROW together any of the tender, green, and succulent parts of recent vegetables, whether acid or alkaline, in a large heap, in the warm open air, and press them down with an additional weight, if their own be inconsiderable; and the middle part of the heap will, in a little time, spontaneously conceive a small degree of heat, and pass successively thro' the other degrees, till it comes to a state of ebullition. In the space of three days, from the first putting them together, they will yield a heat, perceivable by the hand, equal to that of the human body in a state of health; by the fifth it will be too great for the hand to bear without pain; and lastly, by the sixth, seventh, or eighth day, the juices will generally appear ready to boil, and sometimes the matter will even flame and burn away.* (2.) *By this spontaneous operation, the vegetable acquires an abominably putrid, stercoraceous, or cadaverous, taste and odour; and turns entirely into one soft, similar, pappy mass, or* crassamentum, *greatly resembling fetid human excrement in scent, and putrefied flesh in taste.* (3.) *If now this fetid matter, thus obtain'd, be directly, whilst it remains in its fetid state, committed to a glass retort, and distill'd with proper degrees of fire, there will come over,* 1st, *A water impregnated with an urinous spirit, perfectly like that obtainable from animal subjects, and separable by a fresh distillation, slowly made in a tall glass, into elementary water, and a large quantity of pure, white, volatile, dry alkaline salt, not to be distinguished from animal salts.* 2dly, *A volatile, alkaline, oily salt, that shoots in glebes.* 3dly, *An exceedingly volatile and a thick fetid oil, both which are also entirely like those of animals.* 4thly *and lastly, the remainder being calcin'd in an open fire, affords not the least particle of fix'd salt; just as if the subject had really been of the animal, and not of the vegetable kingdom.* *The process.*

2. This process is truly universal, and holds equally in all kinds of vegetables, tho ever so different in their nature and virtue. I have my self made the experiment in the coldest and most succulent or watry plants, such as purslain, sorrel, *&c.* as well as with the hottest or most acrimonious, such as the spurges, *&c.* and always found it succeed; but the sooner, as the vegetable employ'd contain'd the greater quantity *Its universality.*

tity of oil; tho with the same phænomena. It will likewise succed with dry vegetables; provided they be moisten'd with water before they are thrown into heaps. And thus we sometimes see that stacks of hay will spontaneously take fire and blaze away; especially if it was not well dried in the making. It is a very surprizing thing to consider, that by this means the difference betwixt vegetables may be entirely taken away, and the whole kingdom of them reduced to the same common nature; so that wormwood and tansey, for instance, or sorrel and scurvy-grass, shall appear as one and the same thing; and this thing appear no otherwise than putrefied flesh. Tho sorrel be famed for its power of preserving the animal fluids uncorrupted, whilst they are circulating in the body, and scordium for its embalming virtue, as continuing it in a state of incorruption after death; yet even these plants are themselves thus easily corrupted, and changed into such a kind of putrefied flesh as it is their virtue to prevent. And this is a general law of nature, wisely establish'd to produce wonderful changes in the world, and to prevent the indolence and decrease of matter on our globe; this active principle, or medium, giving an easy and reciprocal transition of vegetable into animal substances, and animal into vegetable.

*Its use in explaining the difference between fermentation and putrefaction.*

3. Hence then we are given to understand the nature and uses of putrefaction, with its difference from fermentation, both in regard of the subject, cause, and effect. Vegetables alone are the subject of fermentation; but both vegetables and animals of putrefaction. Fermentation also requires that its subject be first reduced to the form of a liquid, or at least made capable of floating in one, before it can obtain; whereas putrefaction only succeeds when its subject is half dry, or just barely moist: and this is the reason why must put up into a wooden vessel, does not putrefy; whilst the grapes, from which it was express'd, being thrown in heaps, would presently conceive heat, and run into a state of putrefaction. We see also that vegetable putrefaction is begun and promoted with heat, and finished with coction, which requires a degree of heat much greater than that excited by fermentation, as being capable of causing an ebullition in the plant, and even of turning it into flame: and indeed the immediate cause of fermentation is the motion of the air intercepted between the fluid and viscous parts of the fermenting liquor; but the cause of putrefaction is fire it self, collected or included within the putrefying subject. Again, the effects of fermentation are the production of flowers or yeast, the conversion of the saline part of the fermenting body into tartar, or an acrimonious acid and fix'd kind of salt, and of oils into inflammable spirit, retaining something of the nature of the vegetable; but putrefaction makes all the acid salts volatile and alkaline, renders the oils not spirituous but abominably fetid, utterly destroys what sets the specific difference between one subject and another, and converts them wholly into a soft pulpy mass, of an animal nature, without the least signs of

any fix'd ſalt; tho the recent vegetable would, by calcination, at firſt have afforded a large proportion: or in ſhort, making nearly the ſame kind of alteration in the whole ſubject, as it would undergo by paſſing thro' a ſound animal body, ſuffering all the actions thereof, and being at length returned in the form of excrement. And this may let us a little into the nature of animal digeſtion, or the change which the aliment ſuffers in the human body. It is certain, that tho a man ſhould live entirely upon acid vegetables, eat acid bread and fruits, and drink nothing but *Rheniſh* wine, that no part of his body, as the fleſh, blood, bones, *&c.* or its excrements, as the urine, ſweat, fæces, *&c.* would afford the leaſt portion of an acid, or fixed ſalt, by diſtillation, but conſtantly a volatile alkali, by whatever contrivance the experiment is fairly made; and this in as great perfection as if the aliment taken in had been putrefied, and analyzed in the ſame manner: whence, if animal digeſtion be referable to any chemical operation, it ought doubtleſs to be that of putrefaction, rather than fermentation. But to ſay the truth, there is never any perfect putrefaction performed in the living bodies of animals; for as ſoon as any thing contained therein has a tendency to this alteration, it is immediately diſcharged, along with the excrements, as by ſtool or urine. All the acids of the aliment are therefore ſubdued by the vital powers of animals, and converted into volatile ſalts of an alkaline nature; yet without a real or actual putrefaction, tho by an operation that nearly approaches to it. The ſalts and oils thus taken into the blood, and mix'd with the juices, are detain'd in the body ſo long as they remain benign and friendly to it; but, as we ſaid before, when once they alter their nature, or begin to putrefy, they are immediately thrown off; as may appear by the ſharpneſs, fetid ſcent, and particular examination of the urine in ſuch caſes: otherwiſe grievous diſtempers would be excited, that muſt of neceſſity ſoon end in the death of the animal.

4. And now we have gone thro' all the general and fundamental proceſſes, which can aſſiſt and forward our inquiries into the ſubjects of the vegetable kingdom; and according to which all of the like kind ought to be conducted. We have ſeen the ſeveral methods of diſtilling waters, their differences, and upon what principles their virtues depend; we have ſeen all the ways of extracting, ſeparating and making infuſions, decoctions, ſapa's, defruta, extracts, ſalts, oils, balſams, roſins, ſpirits, vinegars, fixed alkali, earth, *&c.* and of procuring all that the fire will obtain from vegetables, by the various treatments or operations practiſed among chemiſts; we have alſo ſeen the effects of difrent combinations of theſe ſimple productions, and what may, by this method, be obtained; *viz.* tinctures, quinteſſences, ſoaps, elixirs, *&c.* by exhalation, decoction, extraction, cryſtallization, and calcination; and laſtly, we have ſeen that ſtrange effect of fire, putrefaction. And thus, in one word, to recapitulate what we have been doing by an example, if we would *Recapitulation.*

procure all the active powers of any vegetable, as of rosemary, for instance, we are taught, by the preceding processes, to exhale, and catch its vapour, get its essential oil by distillation, its native salt by expression and crystallization, its fixed salt by calcination, its inflammable spirit by fermentation, its tincture or elixir by composition and digestion; and lastly, its animal principles by means of putrefaction.

SECT.

# SECT. II.

## *Exhibiting a Courſe of* PROCESSES *upon* ANIMALS; *the more compound Claſs of Organical Bodies.*

### PRELIMINARIES.

1. BEFORE we enter upon the chemical analyſis of animals, there are ſome general and fundamental propoſitions to be laid down from the principles of medicine; the truth whereof is ſo clear and well eſtabliſhed, that they may falſely paſs for axioms.

2. The bodies of living animals are continually waſting and repairing in all their parts.

This propoſition is ſo clear, as not to admit of a doubt. The truth of it is evident, even in the hardeſt and moſt ſolid parts of animal bodies. The nails and hairs which are once cut, ſoon grow to their former length; the bones that were broken, join together again in a few days time; and the teeth, and all other ſolid parts wear by frequent uſe, tho no ſenſible diminution is found of their ſubſtance. But if the ſolids thus conſtantly fly off and recruit again, the fluids muſt unqueſtionably do ſo too. And in effect we ſee that animal bodies increaſe every way, from the ſmalleſt phyſical point till they arrive at their full ſize.

3. Animals, therefore, muſt neceſſarily be compoſed of what they take in as aliment; which, by their vital powers, is converted into their own ſubſtance.

Perhaps alſo the bodies of animals may receive part of their aliment from the air; for, as *Malpighi* has curiouſly obſerved, eggs gain in weight

whilst brooded upon by the hen; which addition of matter, must either proceed from the effluvia of the hen, or from the atmosphere. But that it did not come from the hen, is manifest, because in *Egypt* chickens are frequently hatched by the heat of an oven.

4. The food of all animals is either of a vegetable or animal nature.

There are two kinds of animals, that differ as to their food; those which feed entirely upon vegetables, as the ox; and those which devour the flesh of other creatures, as the lion: but man is an animal of an indifferent kind, that can support himself either with vegetables or flesh, alone. Thus there have been those among the *Pythagoreans* and *Brachmans*, who entirely liv'd upon vegetables; as being obliged by oath to eat no kind of animal.

5. The bodies of all animals, therefore, and even those of men, consist either mediately or immediately of vegetables.

The greatest part of the animals which men use for food, are themselves immediately fed with nothing but vegetables; as sheep, oxen, rabbits, *&c.* But fish, indeed, often take down insects, and so do some kinds of fowl; but then those insects were either fed with vegetables, or it will come to that at last. And, therefore, it is evident, that in order to have a just chemical knowledge of animals, we ought to begin our analysis with vegetables, of which they consist; and this we have done in the preceding processes, to lay the foundation for those which are to follow. A neglect of this observation has introduced a deal of confusion into the writings of chemists and their courses.

6. The method, therefore, in which we are farther to proceed, requires us first to analyze that part of animals which has received the least alteration in their bodies, or but just begins to lose its vegetable, and put on an animal nature.

7. This part must be such a fluid, as proceeding originally from a vegetable, has felt the vital forces of the body, mixed with the blood, passed thro' the arteries and the veins, and been soon separated again. And this can be no other than chyle from vegetables, turned to milk, and separated in the breasts.

It would be improper here to make choice of the chyle it self; this being plainly a vegetable juice, as not having been yet receiv'd into the body, circulated along with the blood, or participating of the nature of an animal fluid. The excrement could not be chose for this purpose, because it loses its vegetable nature in the intestines; and besides, is really no part of the animal body, as having never past the heart, or circulated with the blood. Nor has any other fluid in the body so good a title to our first experiment upon animals, as the milk; this being only animal in the first degree, and differing but one remove from chyle it self, which may well be esteemed a vegetable. But if, instead of this primary animal fluid, we should begin our future processes, as all the famous chemists have done, with analyzing the flesh, the horns,

or the hoofs of animals, which are among the last productions of nature, we should strangely break in upon that delicacy of order which makes a principal beauty, and is indeed absolutely required in a course or body of chemistry, that should be generally useful.

8. All the parts of animal bodies, as well solid as fluid, may receive their nutriment and growth from milk alone.

There have been instances of those who lived upon nothing but milk; and the body of a child, at the end of some months after its birth, is little more than a composition of the milk of the mother; the parts it brought with it into the world being changed for others supplied by the nutriment, in the same manner as the body of an ox is a composition of grass. Thus, by the vital actions, the milk is made to pass thro' all the changes of blood, serum, lympha, nervous fluid or animal spirits, which seem to be the immediate matter of nutrition to all the solids *.

9. The milk of such animals as are only fed with vegetables, being drawn from the breast, and permitted to stand in a warm place, soon separates, of its own accord, into a light and white kind of oil, which rises to the top, and is called cream; and into a thinner, aqueous, bluer, and more ponderous liquor, vulgarly call'd, when the cream is taken off, by the name of skimmed milk.

The milk of the several kinds of animals differs but little, as to its smell, taste and other properties: but that drawn from the breasts of women is the sweetest; the nearest whereto is asses milk, which indeed has a saccharine sweetness, and comes almost up to the human. This is succeeded in virtue and goodness by that of mares, which is better than that of goats; yet even this exceeds that of sheep, as theirs does that of cows, which is the coarsest of all.

10. Neither of the two parts into which new milk spontaneously separates, is of it self either acid, alkaline, or acrimonious, to the smell or taste.

It is true, indeed, that these parts turn acid by standing for some time; but this does not infer, that, contrary to all the evidence of our senses, they naturally contain any acid. Neither are they in the least acrimonious; for being let fall into the eye, they cause no manner of pain, or sensation of sharpness.

11. From these axioms, or general truths, we may draw the following corollaries, which are no less certain than they. (1.) All the parts of the human body might once materially exist in the form of milk. (2.) Chyle, tho really a vegetable fluid, is an imperfect milk, or the rudiments and basis thereof; and exhibits many of the phæno-

* This the learned author has, by an elaborate chain of arguments, in his admirable *Institutiones Medicæ*, made to appear very plausible, but it is question'd whether the actual existence of animal spirits has been sufficiently proved to cause such an hypothesis to be relied on. A close attention to the thing, will perhaps discover, that nutrition, and other actions of the body, may be accounted for without pressing animal spirits into the service.

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mena afforded by vegetables; particularly in its flatulency, the effervescencies it occasions, *&c.* (3.) Milk is a kind of emulsion, or white oily, animal liquor, prepared originally from vegetables by mastication mixing with the *saliva*, the bile, the pancreatic juice, the blood, circulating with it, and being at length separated from it in the breasts. It differs, however, from a true vegetable emulsion in two respects; *viz.* first by coagulating into a curdy matter with acids, capable of forming cheese; which chyle, and all true emulsions, will not do; the utmost that acids can here procure being a taphaceous or chalky kind of substance, but never a cheesy matter: and secondly, acids precipitate a larger quantity out of it than they can do out of emulsions. These particulars being premised, we may proceed to our experiments upon animals.

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## Chemical History *of MILK.*

### PROCESS LXXVIII.

*Proving that new* MILK *is neither acid nor alkaline.*

*The process.*

1. *To any quantity of warm new milk, pour oil of tartar* per deliquium, *or any other alkali, and no effervescence will at all be thereby excited, but the whole body of the liquor remain at rest, tho it appear somewhat thinner.* (2.) *To another quantity of warm new milk, pour, in the same manner, spirit of nitre, or any other strong acid; and again no motion or ebullition will appear; only the milk will presently after become thicker than it was.* (3.) *Now mix together the two parcels of the milk with which the experiments were made, and a great effervescence will immediately arise.*

*The truth it is designed to manifest, confirmed.*

2. The phænomena and effects will be the same, whatever alkalies or acids, even tho of the strongest kind, are pour'd to the milk: whence we may fairly conclude, that new milk contains neither acid nor alkali; for if either of these were latent in it, the process ought to make the discovery, as being generally allow'd the proper criterion. And, accordingly, in the latter part of the experiment, when the two parcels of milk, containing the one an alkali, and the other an acid, come to be mix'd together, these presently manifest themselves by the conflict they make. And thus also, by the common trials with syrup of violets, or the like, mix'd with new milk, no acid or alkaline parts can, from a change of colour in the syrup, be discover'd, any more than by the direct examination of the senses: if, therefore, any one after this,

shall say that new milk is acid, because it may be made so by art, or turns sour of its own accord by standing, he may, with as much justice, pretend that there is alkali contain'd in vinegar, tho no signs of it appear; because alkali may be naturally or artificially obtained from it. But this is changing the nature of things, and retaining their names; for in such a case, milk is no longer milk, nor vinegar the thing that its name implies.

## PROCESS LXXIX.

### *Shewing that* MILK *turns acid by* Digestion.

1. *LET any quantity of new milk, drawn, from a sound animal, that feeds only upon vegetables, at the distance of about eight hours from her feeding, stand to digest in a clean, open vessel of glass, with a heat equal to that of a man in health, and it will soon begin to throw up to its surface a thick, unctuous, creamy or butyraceous part, which will thus rise in a considerable quantity; a much larger proportion of a thinner or serous liquor remaining below. Both of them at first are sweet to the taste, or manifest no kind of acidity; but by degrees they both turn tart; and at the end of twelve days, from the first of the operation, attain their highest degree of acidity, which is very considerable.* *The process.*

2. This process will be the sooner finished in summer, by reason, as well of the additional warmth, as of the tart, juicy herbage whereon the cattel feed in that season of the year; but it proceeds slower in the winter, when they feed on hay: yet, even in this cold season, it will at length succeed. But if the milk for this experiment be drawn from such animals as feed solely upon flesh, or have been withheld from food for twenty-four hours, such as labour under feverish disorders, or have just before performed some extraordinary motion, or undergone hard labour, it will rather putrefy, or turn rancid, and run into ichor, than change of an acid nature. One of the first signs of this disposition, is its saline taste; so that it always may be concluded, that when milk is brackish upon the tongue, it then begins to putrefy. *Whence performable with different events.*

## PROCESS LXXX.

### *Shewing that boiling* MILK *will strongly coagulate with acids.*

1. *GRadually pour spirit of nitre, or any other acid, to a quantity of milk boiling over the fire, and no conflict will be made thereby; but the liquor will presently divide into two very different parts, the one thinner, and the other much thicker than milk, notwithstanding the action of the fire upon the matter.* *The process.*

2. The

*Its phyſical uſe.* 2. The effect is found to be the ſame in all the kinds of milk yet known; which by this means are formed into curd, whereof cheeſe is made; and a clear thin liquor, or ſerum, which now turns ſpontaneouſly acid. The coagulum formed upon this ſeparation, may, by preſſure and the evaporation of its moiſture, in time be reduced almoſt to the hardneſs of ſtone; as we ſee in ſome particular ſorts of cheeſe: ſo that it is no wonder that bones made out of milk are of that ſtrength and ſolidity we find them. Something of this kind will alſo happen in emulſions, but in a leſs degree; for which reaſon, when we preſcribe emulſions, we ſhould be cautious not to mix acids along with them.

*Its medicinal uſe.* 3. This proceſs may ſerve to ſhew us in what caſes or conſtitutions it will be improper to uſe milk: for if it ſhould be taken by perſons whoſe bodies abound with acids, the ſame thing will neceſſarily happen there as did in our experiment; that is, the milk will be ſeparated into a thin, ſerous fluid, and a ſtrong coagulum, which, turning grumous, may cauſe obſtructions in the viſcera; whilſt it ceaſes to be mixed and diluted with the ſerum, that inſtead of performing this office, may now go away in fetid ſweat, leaving the body pale, faint, and weak. And this unheeded cauſe may give birth to a pale complexion, a cacochymia, and various chronic diſeaſes.

## PROCESS LXXXI.

### *Shewing that* MILK *turns red by being boiled with alkalies.*

*The proceſs.* 1. I*F to a quantity of new milk, made boiling hot by the fire, any fixed alkali, as the ſalt of tartar, or its oil run* per deliquium, *be added by degrees, there will a lighter kind of coagulum be made than was before produced by the acid; and the milk, by boiling, will preſently change to a yellow colour, and run thro' all the intermediate degrees, till at length it ſtops in an intenſe red.*

*Its phyſical uſes.* 2. The coagulum, and changes of colour, will be the ſtronger and more ſuddenly made in proportion to the ſtrength of the alkali, and continuance of the ebullition. Whence we may ſee that milk has a very great propenſity to turn from its native white, into a red colour. The milk of all animals, in a ſtate of health, is naturally white; whatever be the colour of the aliment they take in; and will exhibit the ſame phænomena by the treatment of this proceſs: or if the alkali be very ſtrong, and the operation continued long, it will change at length into a dusky red, or dark brown, and even a black colour. Whence it is eaſy to ſee why the chyle ſo readily changes into a red liquor, or blood; for the animal juices, with which it mixes in the body, contain no acid, but rather incline to an alkaline nature. And when any animal, that gives ſuck, becomes feveriſh, the milk turns from its genuine whiteneſs to a yellow, and becomes, in a manner, ſanious and coagulated. When the milk of a

a nurse is in this state, the infant manifests a very great aversion to and dislike of it: and if the fever continues long, the breasts grow hard, and at length impostumate, so as to prove of difficult cure. The generality of physicians will needs have these disorders to proceed from a certain, imaginary, peccant acid in the body; when nothing can be plainer, as may be learnt from our present process, than that they are owing to the action of an alkali. And hence it was, that in the terrible contagion which happened among the cows in *Holland*, in the year 1714, their milk proved exceeding thick, yellow, and almost putrefied, before it came from them. And what is very surprizing, this change was made in it so suddenly, that a country-man, of whom I had but the evening before purchased some pure, white milk for chemical experiments, complain'd to me the very next morning, that he could now get nothing from the same cow but a thick, pappy, yellow matter, instead of milk.

3. What we have hitherto shewn of milk holds true, provided it be drawn from any of those animals that feed entirely upon vegetables; and at a time when they are in a state of health: but if the creature which afforded the milk, labours under any violent distemper, either of an acid or putrid nature, the phænomena will be quite different. And the same must be expected, if the animal that gave the milk feeds only upon animals. The physicians who prescribe to the diseases of infants, ought carefully to regard these observations; for if a nurse should entirely abstain from acid vegetables, as wine, malt-liquors, *&c.* and use only water, or the decoction of animal substances, for her drink, and feed upon nothing but the flesh of animals, as fish, *&c.* her milk would scarce be capable of turning sour, but would rather putrefy and smell strong like urine; and the child that drew her breast, would never be free from a fever: which is too often the case of the infants of wealthy parents; the nurse being preposterously withheld, by the tender mother, from the use of whatever food is of an acid nature; and confined to live altogether upon animal diet, as the most nutrimental. On the contrary, the children of the poor, whose mothers are principally sustain'd by food of an acid nature, or what in some measure inclines thereto, are much less subject to fevers; but oftener afflicted with those diseases which owe their rise to acids. The cure of both cases is best effected by a change of diet in the nurse, from alkaline to acid, or from acid to alkaline. Thus when the diseases of young children proceed from an acid cause, which may be learnt from the scent of their fæces and eructations, as also from a preternatural distension of the body, and paleness of the flesh, the diet of the nurse should consist of fish, flesh, and the liquor in which they are boiled; the use of bread, wine, and other things of an acid nature, being forborn. But if the infant labours under a burning fever, appears red, hot, *&c.* the nurse should be treated in the contrary manner, with acids, or such aliment as is tart and cooling. And thus we are taught the nature of that liquor of

*Its medicinal uses.*

which the human body may be entirely composed; and which receives so sudden an alteration therein, that no signs of it can be found twelve hours after it is once admitted into the blood; as the excellent Dr. *Lower* has shewn by experiment. Upon which account no woman that gives suck ought to fast above twelve hours, if she would afford good milk to the infant at her breast. Hence, likewise, we are given to see the reason of some phænomena both in acute and chronic diseases; as particularly the redness and heat of the body in the former, and its paleness, *&c.* in the latter; these generally proceeding from an acid, and those from an alkaline cause. And hence, lastly, we learn a necessary caution in the choice of a nurse; *viz.* that her milk be perfectly white; a tendency to yellowness in it being a sure and early symptom of a fever.

*Introduction to the history of urine.*

4. Our method next leads us to examine that fluid, which of all those in the animal body, is first secreted after it has undergone an entire course of circulation thro' the vessels and viscera. And this we pronounce to be the urine of a sound animal, discharged at the distance of twelve hours from taking any thing by way of sustenance; the bladder also having just before that time been emptied of its contents. We do not make choice of the blood for our next experiments, because all its parts are too confusedly blended and locked into one another to be fit for this purpose; whereas in urine, the oils, salts, spirit and earth hang looser together; having but just entirely put on an animal nature, by which, however, it is perfectly distinguish'd, and made widely to differ from vegetables.

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# CHEMICAL HISTORY *of URINE.*

## PROCESS LXXXII.

### *Shewing that* URINE *is neither acid nor alkaline.*

*The process.*

1. *TAKE any quantity of fresh urine, that has not been above twelve hours contained in the bladder, and add to it oil of vitriol, or any other acid liquor, at discretion; and no manner of conflict or effervescence will be made between them. In like manner, add to another parcel, oil of tartar* per deliquium, *or any other known alkali, and the mixture will lie quiet as before, or give not the least signs of any ebullition: whence it may be justly inferred, that such urine is neither acid nor alkaline; as standing the test of the experiment allowed sufficient to make the discovery.*

2. The urine made choice of for this experiment, ought to be that of the morning, or discharged at the distance of twelve hours after any meal, that it may be a perfect animal fluid: nor should it be suffered to remain for any longer time in the bladder, lest it might thereby begin, as it were, to putrefy, or acquire something of an alkaline nature. The bladder, therefore, should here be emptied before the last meal is made. But if the urine be taken twelve hours after feeding, it will then be perfect and thorowly concocted; no chyle, or matter of a vegetable nature, as was before observ'd, appearing in the blood, after the expiration of that time, without a fresh supply of food; so that the aliment then taken in, may now it is mixed with the blood, be justly esteemed a part of the body. *What cautions it requires.*

3. Human urine is a recrementitious liquor, confessedly drained from the whole mass of blood, after it has washed both the solids and fluids; and therefore cannot but excellently discover to us the nature of the salts contain'd in our bodies. Accordingly, if we examine it by our senses, we shall find it to the taste considerably more saline than the blood it self: but its scent, when fresh, is no ways nauseous or disagreeable, but somewhat grateful, pungent, and odoriferous. *Galen* tells us, "that "the urine of a man in health is straw-colour'd, or of a pale yellow, and "contains but little sediment, or fæculent matter; being in effect a "lixivium, in which all the salts of the body are dissolved and washed "away:" and indeed this appears to be the very fact. But if either alkaline or acid salts were naturally contain'd in the urine, our present process must needs make them manifest. But neither this, nor the common experiments made with the syrup of violets, *&c.* will discover such kind of salts in the urine of healthy persons; and therefore we must, in justice to our senses, as well as experiment, conclude it contains none. Nay, I have, in like manner, examin'd the urine of a man who had lain for twenty-four hours ill of a fever, without eating or drinking; yet could not, even in that, discover any signs of an alkali or acid salt, either by its making any effervescence with known alkalies or acids, or changing the blue colour of syrup of violets to red or green. With the same view I have strictly examin'd the urine of a man who liv'd almost entirely upon acids; but could find no proofs of acidity therein. And these experiments will hold true universally, where the urine is fresh, and procured in its natural state, or from healthy persons: but it must be expected, that a difference in circumstances will vary their success. Thus if a man should have a stone in his bladder, this might occasion the urine to appear of a more alkaline nature than if he had none; or drank scarce any thing more than acid wines or vinegar; especially if the urine be made and examined presently after the drinking of such acid liquors: for in that case, not having had their due circulation, they may in the form of urine still retain something of their prior nature. And so, likewise, in any diseased state of the body, the urine, or other humors, may change *The truth of it confirmed.*

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from what they naturally are, and become either alkaline, as in a burning fever, near the point of death, *&c.* or acid, as in the *pallor virginum*, childrens diseases, *&c.* But it is not of such distempered urine that we are now speaking.

## PROCESS LXXXIII.

### *Shewing, by the distillation of recent* URINE, *that the parts into which it is resolvable, are neither acid nor alkaline.*

*The process.* 1. T*AKE any quantity of fresh urine, obtain'd with the conditions above specified, and distil it gently in a clean, glass retort, with its receiver, and there will first rise a limpid water of a fetid or unpleasant scent; but resembling that of roasted flesh, containing neither a visible oil nor salt, and proving, upon the proper trials, neither acid nor alkaline, nor any way saline, or inflammable.* (2.) *If, after all this water is come over, what remains at the bottom of the retort be examin'd in the same manner, it gives no signs of its being either of an alkaline, or acid nature; and if distilled or exhaled still farther, as to the consistence of a syrup, or higher, it gradually changes its original straw-colour, to that of a yellow, a red, a brown, and lastly to a black, according to the quantity of water drawn from it, and appearing at length in the form of a saponaceous mass, that will not, like some other animal fluids, as the serum, white of eggs,* &c. *concrete by the fire.* (3.) *And lastly, if this soapy matter be calcin'd, it will afford a quantity of sea-salt, if the animal, or person from whom it was obtain'd, hath used any in his food: but if that be not the case, there will be no signs of any fix'd salt at all.*

*Its physical and medicinal uses.* 2. The saliva, the serum, the bile, and other animal fluids distill'd in the same manner, afford a water of a somewhat unpleasant, indeed, but not a fetid odour, like that of our present process; as containing less oil, to which that scent is owing, and upon account whereof the liquor is perhaps said to be spirituous: nor does the urine of any other animals, fed with vegetables, so far as I have tried, yield such an one. And it is remarkable, that the more healthy and strong the man is, the more fetid this water distill'd from the urine proves; yet it appears not at all either of an acid, or alkaline nature, in any of the experiments I have ever made. We see likewise, that this water contains no inflammable spirit; whence it is manifest, that no such ever passes the urinary canals; tho fermented liquors are drank in very large quantities. For tho a man should take down four or five pints of wine at once, yet his urine distill'd at the distance of twelve hours from his drinking, would not appear in the least spirituous; but yield a very fetid water, like that afforded by the urine of a patient in a fever. I can speak positively in this case, because I have frequently distill'd the urine of great drinkers, on purpose to see what it afforded. And hence we may learn, how it comes to pass, that the drinking of strong liquors so remarkably affects the brain;

brain; and see the reason of the observation of *Hippocrates*, that great drinkers generally die apoplectic. Since therefore it appears, that there are no alkaline salts contain'd in the urine, we may justly conclude, that no such are contain'd in the human body, for if any alkaline salt did really, and in its own form, exist in the fluids of the body, it ought certainly to be found in the urine; because such salt joins it self with nothing more readily than water, which makes, as we see, a principal part of the urine; and therefore cannot but dilute, dissolve, and bring away with it the saline matter of the body. But altho neither alkaline, nor acid salts can be found in the human body, yet in ardent fevers, the plague, *&c.* the juices may, by the great increase of the circulation, and the violent heat, be turned of an alkaline nature; or become so sharp and corrosive, that unless they are discharged thro' the kidneys, they may presently destroy the tender fibres of the *cerebrum* and *cerebellum*, and so prove mortal. But if their subtil, or too much attenuated salts be determin'd to the bladder, along with the urine, the patient will from that time begin to recover; whilst the physician suffers the morbific matter to go off uninterrupted thro' the urinary passages. And indeed it were easy to conjecture, from the peculiar fetid scent of the urine, above that of all other fluids, that the kidneys are an organ design'd by nature to throw out of the body, any thing that, by being too much attenuated, cannot be longer detain'd with safety to the vessels of the brain, or the life of the individual. And therefore the urine, tho it has neither acid nor alkaline salts, yet actually contains the sharpest in all the body; being with the oil, which brings them to a kind of soap, of a very deterging nature. And accordingly, as they all come closer together in our experiment, by the evaporation of the aqueous parts, they appear of a deeper colour; just as in a fever, when the increas'd heat of the body has exhaled the more volatile or aqueous parts of the fluids, the urine becomes high colour'd, or intensely red, or sometimes even black: whence we may learn to prognosticate the turn of a distemper from the urine. This process likewise lets us see how contrary to truth that general opinion is, which supposes, fix'd alkalies, acid salts, or fermented spirits produced in the human body, to be the cause of all diseases.

## PROCESS LXXXIV.

*Shewing, by the distillation of recent* URINE *with dry sand, that it will afford a volatile, alkaline salt*, &c.

1. *EXHALE recent urine, over a gentle fire, to the consistence of a syrup, or thin honey; and afterwards add to it four times its own quantity of clean, dry sand, or so much as will reduce it to a thick paste; then distil this mass in a glass retort, of which it fills only two thirds, with degrees of of fire, in a sand-furnace; and the first thing that comes over will be a* *The process.*

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*large quantity of pure water or phlegm, as in the last process. (2.) Upon changing the retort, a transparent liquor ascends, and runs in veins, like oil, down the sides of the glass, called by the name of* Spirit of Urine; *which will cause a strong effervescence with acids; and by rectification resolve into a dry white salt, a water, and an oil. (3.) Upon continuing the fire, white fumes will next arise and fill the receiver; and at the same time, a large quantity of strong, volatile, alkaline salt will fix it self to the sides thereof; and this has been falsely supposed the same with sal-armoniac, which is not of an alkaline nature. (4.) Then upon increasing the fire, there will ascend a light yellow fetid oil; and at last, a gross, heavier, and still more fetid kind. (5.) But if the remainder be now calcined in an open fire, and afterwards brought into a lixivium with water, it yields a sea-salt, provided the animal which afforded the urine, took in that kind of salt with its food; otherwise there will not be left, after the operation, the least imaginable portion of fixed salt.*

*Its physical and medicinal uses.* 2. And hence we learn the effect of a considerable degree of heat upon the salts of the human body. The urine distilled, or exhaled away with a gentle fire, affords no alkaline salt at all; but a greater degree thereof gives it an alkaline nature, or causes it to afford an alkaline salt by distillation. And thus we find, when a man has given an uncommon motion to his body, or begins to grow feverish, his urine will smell strong, and appear of a red colour, or like *lixivium;* which shews that the salts and oils thereof are attenuated. But tho it be certain that the salts of the body become alkaline by heat, yet it is hardly possibly they should be so far attenuated, or broken therein, as to appear such in the urine; not only upon account of the languid heat of the body, but because in all probability, as was before observ'd, the tender vessels of the brain, *&c.* would be destroy'd by the corrosiveness of such salts, and the death of the person effected, before they were rais'd to that degree of acrimony.

## PROCESS LXXXV.

### *Shewing that recent* URINE, *by being distilled with fixed alkali, is it self turned of an alkaline nature.*

*The process.* 1. *To any quantity of recent urine, inspissated in the manner of the precedent process, add an equal proportion of fix'd alkali; and distil them together in a glass retort, with a gentle fire: there will immediately come over first a sharp, volatile, fetid, alkaline spirit, that makes a thorow effervescence with acids; and soon after, a dry, volatile, alkaline, solid salt, which without the addition of the fixed alkali, would have been of the same kind with that of the last process; a saponaceous mass remaining at the bottom of the receiver.*

*Its physical and medicinal uses.* 2. Hence it is easy to imagine, that, besides the peculiar and acknowledged effects of fixed alkaline salts in the human body, they have more-

moreover, the power of immediately rendring our native ſalts of a ſharp alkaline nature, and acting upon them like ſo much volatile alkaline ſalt introduced into the body; thereby they turn our half-fixed ſalts into ſuch as are truly volatile; thoſe that before were of a benign gentle nature, into ſuch as are fiery; thoſe that were neutral and innocent, into ſuch as are corroſive, *&c.* on which account they act like poiſon in all ſuch diſtempers where the ſalts are too much attenuated; as in acute fevers, inflammatory caſes, *&c.* And hence we may learn *à priori*, what *Hippocrates* was taught by hazardous experience, to order nothing but acids, or medicines tending to an acid nature, as oxymel, *&c.* in ſuch kind of diſtempers.

## PROCESS LXXXVI.

*Shewing that recent* URINE *diſtilled with quick-lime, affords a fiery, yet not alkaline ſpirit.*

1. *WITH the rob, or ſapa, of recent urine, mix an equal quantity of quick-lime, in a tall glaſs-veſſel, fitted with a receiver, and a violent ebullition, with a great degree of heat, will immediately enſue; and at that very inſtant there will ſwiftly fly off from the mixture, and paſs over into the receiver, a clear liquor or ſpirit of an exceeding fiery and pungent taſte and odour; yet not of an alkaline nature, or capable of cauſing an effervescence with acids.* *The proceſs.*

2. This is as volatile, moveable, and corroſive a liquor as any in nature; and if the veſſel that contains it be left careleſsly ſtopp'd, tho but for a day or two, it loſes all its virtue, and becomes a mere inſipid water. It is truly of a fiery nature, being more of a cauſtic than fix'd alkali it ſelf; ſo as inſtantly to eat away the skin, and affect the nerves. Whence we are given to underſtand the effects of quick-lime, and its lixivium upon the human body; and ſee that in the twinkling of an eye it can give a ſtrange degree of volatility, and at the ſame time a moſt corroding, active, and fiery nature to all the ſluggiſh ſalts it meets with there. Hence it is evident, that the human ſalts may have a violent degree of acrimony, or corroſiveneſs, without giving any ſigns of an alkaline diſpoſition; as ſcarce any chemiſt, beſides the excellent Mr. *Boyle*, has obſerved; for the ſpirit of our proceſs will quietly mix with acids, or make no manner of conflict with them; ſeeming to conſiſt of ſalts, which by the lime are turn'd entirely into the nature of fire. This makes it not improbable, that the plague is no more than a change of the human ſalts, into thoſe of an igneous nature; effected by means of certain effluvia floating in the air of peſtilential places, and having the power of inſtantly pervading the human ſtructure, and thus burning up or deſtroying its vital parts, or faculties. There is one phænomenon which ſeems to give great countenance to this conjecture; the diſcolouration and blackneſs *Its phyſical and medicinal uſes.*

blackness of the skin, which appear as if they were occasioned by the action of some caustic salts. We see, therefore, that in all cases where the salts of the human body are already too much attenuated, or rais'd to a great degree of volatility, this fiery liquor, tho neither acid, nor alkaline, is violently or suddenly pestilential or poisonous; and on the contrary, where all the vital faculties languish, as in apoplectic or lethargic disorders, 'tis a most immediate and powerful remedy; tho it ought to be used with the greatest caution. And hence we are furnish'd with an admirable rule for the medicinal use of the lixivium of quick-lime, or other medicines prepar'd therewith; which can only be proper in cold, phlegmatic, and sluggish or languid constitutions, or dispositions of the blood and juices; and, on the other hand, very pernicious, or even destructive, in thin, hectical and vigorous habits; or such as are subject to the phthisic, *&c.* because in these cases it sets the salts still more at liberty, and determines them as it were, to a state of putrefaction; to which, by the nature of the distemper, they are already too much inclined. And hence we may learn the cause of that phænomenon which seems to have perplexed the gentlemen of the royal *academy* of sciences at *Paris*; *viz.* why the lixivium of quick-lime is so excellent a medicine against the chronical diseases of northern regions; yet very unsuccessfully or fatally prescribed for the same diseases in *France*, *Italy*, and the southern parts of the world. For as the inhabitants of southern regions are naturally lively, brisk and agile, their juices, without question, are very fluid, and consequently their salts attenuated or broke small; so that a lixivium of quick-lime, which produces those very effects in the body, cannot but be prejudicial to them; whereas, in colder climates the human salts are lock'd up in much more viscid fluids, and wanting to be extricated and set free, the lixivium of quick-lime admirably answers this end, and cures the chronic diseases to which the inhabitants of such climates are subject. Thus the scurvy, the principal disease of that kind, is very successfully cured in *Holland* by taking an ounce or two of this lixivium every day, for some continuance. But for the same reason it ought never to be given in bilious and sanguine habits. For the effect of it, we see, does not depend so much upon the lime it self, as it does upon the humours it shall happen to meet with in the body, and the manner wherein it mixes with, and prevails over them, as *Helmont* judiciously remarked.

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## PROCESS LXXXVII.

### *Shewing, that recent* URINE *will crystallize by inspissation, or afford an* essential salt.

1. *Evaporate a large quantity of the recent urine of a healthy man, to the consistence of a syrup, with one continued degree of heat; separate the oil from it by the filtre, and afterwards put it into a close vessel, and set it in a cool cellar, for the space of one year; it will shoot into a thick, brown, saline glebe, or crust, at the distance of an inch or two from the bottom of the vessel: then carefully pour off all the liquor that floats above, take out the mass of saline crystals, and lay the matter at the bottom thereof aside for phosphorous. These crystals, which are of a peculiar nature, being dissolv'd in pure warm water, filtred and evaporated to a pellicle, and set again to shoot in the cold, will again run into crystals* sui generis, *or a white purified salt, of a nature different from all other salts, and become the purer, the oftener the process is repeated; so that it may justly be call'd the* essential salt of urine, *or of the human body.* *The process.*

2. It may indeed be objected, that this salt is not obtain'd, but by suffering the urine to putrefy; which is true: nor is there any other way yet known of procuring it. Neither will the addition of oil of vitriol, or any other acid, prevent its putrefaction; so strongly is it inclin'd thereto. It cannot however be said, that this is the common, or sea-salt, which will evidently appear upon the comparison; this being totally volatile at the fire; whereas sea-salt remains fix'd in the strongest heat. Neither hath it the properties of borax, nitre, sal-gem, sal-armoniac, &c. but is really a salt *sui generis*, and not to be match'd by any other salt in nature. The process for making it is indeed tedious and laborious; and it cost me no small pains to discover in what manner the salts did really exist in the human body. To do it with the greater advantage, I have evaporated more than two hundred weight of recent urine, and treated it in the method already deliver'd; by which means I came to a knowledge of the essential salt of the human body; and upon trial find that it is of a wonderful diuretic and emmenagogic virtue, yet without any sharpness at all, being neither alkaline nor acid. This salt cannot be so easily obtain'd from the blood or bile, by reason of their grossness, tenacity, and the large quantity of oil wherewith they abound; but readily enough from urine, which is as it were, the lixivium of the blood. *The nature of the production.*

## PROCESS LXXXVIII.

### *Shewing, that recent* URINE *becomes alkaline by digeſtion.*

*The proceſs.* 1. *SET any quantity of recent urine, obtain'd with the conditions formerly mention'd, to digeſt in a tall glaſs, with a heat no greater than that of a healthy man, for the ſpace of three or four days, and it will continually grow more and more red, fetid, cadaverous and alkaline; throwing off a ſtony matter to the ſides of the veſſel.*

*Its phyſical uſe.* 2. The experiment will ſucceed in the ſame manner without the aſſiſtance of heat, by letting the urine ſtand in a well-cloſed veſſel for five or ſix weeks in the cold; but a gentle heat will greatly ſhorten the proceſs. The urine thus digeſted has a fiery lixivious taſte, and will make an ebullition upon mixing with acids; whereby it may in a manner be reduced to its recent ſtate again. Being of this nature, it is of ſingular uſe, as a lixivium, to dyers, and the ſcourers of cloth, in order to cleanſe their wool, or prepare their ſtuffs to receive the dye; for there is always a greazy matter ſticking to wool, whether manufactur'd or unwrought, which hinders the ſtriking of the colour, unleſs it be firſt waſh'd away with a proper diſſolvent; ſuch as the lixivium of quicklime, pot-aſhes, or the like; which coming too dear, digeſted or putrefy'd urine is commonly employ'd in their ſtead, for the purpoſes abovemention'd.

*Its medicinal uſes.* 3. This proceſs may ſerve to point out to us ſeveral uſeful particulars relating to the practice of phyſic; and particularly, 'tis highly ſerviceable in aſcertaining the diagnoſtics of diſeaſes. We learn from it, that if the urine be too long detain'd in the bladder, it will acquire a corroſive, alkaline nature, deſtructive to the body, and capable of changing the colours of other ſubſtances, as we ſee when catheters are thruſt into the bladder, in caſe of a long ſuppreſſion of urine; and the like change will the other fluids receive, by ſtagnating for any conſiderable time, which may give riſe to various diſeaſes. Thus for example, when a perſon is firſt ſeized with the dropſy, he is not at all affected either with a thirſt, or fever; but after the collected water has remained ſtagnant for a ſmall time in the cavity of the abdomen, it preſently cauſes a drought, heat, fever, *&c.* all which ſymptoms proceed from the acrimony of the fluids, acquired by digeſting, as it were, in the abdomen; for upon this, the ſalts and oils of thoſe juices become ſo ſharp, as to corrode the veſſels of the body, and greatly diſturb the whole animal frame. On the ſame account it is, that the putrefaction of the body enſues ſo ſuddenly after death; tho it might, if the fluids had ſtill remained in their circular motion, have continued much longer uncorrupted. Hence we learn, that the bare want of motion in the animal fluids may cauſe violent diſorders, by thus rendring the ſalts and oils more volatile,

active

active, and powerful, or setting their parts free, and leaving them to themselves. Hence stony matter may readily be generated by a bare detention of the urine in the bladder, as in our present process it is thrown to the sides of the containing vessel. And this will happen in the urine of any man, tho not at all troubled with the stone or gravel; the solution or cure whereof it is, therefore, in vain to expect from putrefaction. This separation of the parts of the urine, or acquired alkaline nature, and not its bare quantity, appears to procure the death of the patient in long suppressions of this excrementitious fluid; the effluvia, or fiery alkaline spirit whereof, now, after having stagnated for some days, gets to the brain, and destroys its tender substance. And thus we have seen three ways wherein the salts of our bodies may be rendered volatile, *viz.* by heat, the admixture of alkaline salts; and by their bare stagnation.

## PROCESS LXXXIX.

### *Exhibiting the resolution of* digested URINE *into an alkaline spirit, an alkaline salt, two kinds of oil, phosphorus, earth, and sea-salt.*

1 *TAKE urine digested after the manner of the preceding process, and distill it in a tall glass retort with a gentle fire. The first thing that will come over, is, (1.) A clear fetid liquor, rich in volatile salt, of a fiery acrimony, capable of making a strong effervescence with acids, and consequently of an alkaline nature. (2.) A yellow, volatile, fetid alkaline salt, that appears in a dry form. And if now the remainder be exhaled to the consistence of a sapa or thin honey, then mixed with four times its weight of dry sand, and the distillation be continued in a coated retort, with degrees of fire, there will come over, (3.) A large quantity of a very fetid, brown oil, impregnated with salt, and at length one of a gold-colour; then the retort being taken away, and a much larger substituted, half full of water, and the fire increased to its highest degree, (4.) Blue fumes will ascend, which, in the dark, appear like flame in the vessel. And (5.) With a violent heat there will distil over a gross, shining matter, that sinks to the bottom of the water, and called by the name of solid phosphorus: and here the operation ceases, nothing but an earthy substance remaining behind; which, being boiled in water, cleansed with lixivium, and again dried and calcined, affords a quantity of sea-salt, but none at all that can be called fixed alkali.* *The process.*

2. The process must be stopped after the volatile salt is come over, and sand, powdered bricks, or the like, be mixed with the sapa; otherwise it would swell, and come over all at once in the distillation The gross matter which ascends the last in this operation, will not dissolve in the water wherein it falls; but may, by inclination, be separated from it; and then being exposed to a gentle heat, it will melt *Directions for managing and improving it.*

 like

like wax, and remain capable of being formed into glebes, or pieces of any ſize, which are to be kept continually under water; by which means it may be entirely kept from conſuming, for many years. And this is the ſolid phoſphorus, which ſpontaneouſly takes fire, and ſhines when brought into the open air. It will never fail to do this, provided the operation is managed with care; but it requires the conſtant attendance of the operator for four and twenty hours, to ſee that all the parts are conducted as they ought to be. But to make this phoſphorus more directly, and to the beſt advantage, it may be proper to take a ſufficient quantity of human urine, afforded by a perſon not much given to drink wine, and exhale it away in an open veſſel to a rob, or the conſiſtence of honey; then ſet it to putrefy for half a year, and upon diſtillation it will afford a large proportion of ſalt; after which, if ſix times its own quantity of ſand or brick-duſt be added to the remainder, and the diſtillation be continued as our preſent proceſs directs, the phoſphorus will fall into the water as there mentioned. Or, it may commodiouſly be prepared in the manner of the *eighty ſeventh proceſs*, by ſuffering the rob of urine to digeſt for two years in an open veſſel in the open air; during which time a ſlimy, fæculent, unctuous, earthy matter will be let fall to the bottom; which being frequently waſhed with pure water, wherein it will not diſſolve, it will leave a white matter behind it, neither of an alkaline, acid, ſaline, or terreſtrial, and ſcarce of an unctuous nature: and this is of it ſelf a proper matter for the making of phoſphorus by diſtillation with ſand. A thick cruſt of ſaline matter, ſhot into cryſtals, grows, as we formerly ſaid, upon this fæculent ſubſtance; which being cautiouſly ſeparated, and well waſhed with pure water from the matter of the phoſphorus, gives the eſſential ſalt of the human body. Then all that matter which floated above this ſalt, being mixed with thrice its quantity of ſand, and carefully diſtilled in a cloſe veſſel, with a gentle fire, to dryneſs; there will firſt come over a volatile ſpirit, then a ſalt; which, according to *Helmont*, is wonderfully apperitive: and now, the receiver being changed, there will ariſe a large quantity of a cryſtalline ſalt, of an alkaline nature, and ſtick to the ſides of the glaſſes: and this ſalt, by one rectification, becomes ſo volatile, that it can ſcarce be contained in any veſſel, tho ever ſo cloſely ſtopped. And if the ſpirit be rectified, and kept in a pure glaſs veſſel, it will depoſite a large proportion of a brown ſtony earth; which is by *Helmont* taken for the matter of the ſtone in the bladder. The fire being now much increaſed, a brown and very fetid oil will come over; and at length one of a fine yellow colour, which, when rectified with the ſpirit, *Helmont* takes for the diſſolvent of the human *calculus*. And now the remaining matter being urged with the ſtrongeſt naked fire, in a coated retort, and a very large receiver, half full of water, employ'd, the phoſphorus it ſelf will at laſt come over. It is ſurprizing how long this phoſphorus will continue ſhining, at an inconſiderable

ſiderable expence of its ſubſtance *. And beſides this, there are many ſtrange phænomena obſerv'd of it; as particularly that of its perpetual flaſhing or ſhining on the hot nights of the ſummer-ſeaſon, according to what is delivered of it in the philoſophical tranſactions of *London.* Here again, if the *caput mortuum* be diſſolved in water, filtred, evaporated, and calcined, it will afford a quantity of ſea-ſalt; which gave occaſion to *M. Vieuſſens*, and *M. Homberg*, to ſuppoſe there was an acid ſalt contained in the human body. That this is really ſea-ſalt, is manifeſt by the proper experiments, which ſhew it to have all the characters thereof. In taſte and ſmell it plainly appears to be ſuch; and when added to *aqua regia* will cauſe it to diſſolve gold. 'Tis true, however, that it cannot be made to cryſtallize ſo readily as ſea-ſalt; but this proceeds from the oil with which it is intimately united in the body: for it is a known thing in chemiſtry, that the mixture of any thing unctuous prevents the cryſtallization of ſalts. We ſee then, and may be certain, that ſea-ſalt paſſes unaltered thro' all the conduits and ſtrainers, all the digeſtions and circulations of the body, whoſe vital powers are inſufficient to deſtroy its texture, or change its nature; which is more than even putrefaction it ſelf, or a violent degree of heat, can effect; as plainly appears from the preſent proceſs. The antient adepts, therefore, were well aware what they did in ſaying, gold and ſea-ſalt are the moſt perfect, or indeſtructible bodies in nature, as paſſing thro' others without alteration; and accordingly other ſalts, as tartar, nitre, *&c.* may readily be changed into alkalies; whilſt this conſtantly remains in full poſſeſſion of its native virtues. Its uſe, therefore, ſeems to be to preſerve the bodies thro' which it paſſes from corruption; and particularly the human: it deterges its veſſels, keeps the fluids from running into putrefaction, and prevents the formation of ſtony matter. Whence we learn the reaſon why the antients gave ſal-gem in putrid fevers; and how a mixture of ſea-ſalt and ſulphur came to be ſuch a favourite medicine with *Hippocrates* in peſtilential caſes, or where the juices of the body tended to corruption. *Helmont*, alſo, ſucceſsfully employ'd the ſame ſalt, with vinegar and ſulphur, in the plague. But all manner of vegetable ſalts are entirely changed, or loſe their own nature in the human body, and put on that of a volatile alkali. If an animal were to take in no ſea-ſalt, a thouſand pound weight of his urine would not afford a ſingle grain of any acid or fixed ſalt; whatever were the food he made uſe of. *M. Vieuſſens*, indeed, an author much more ſucceſsful in anatomical inquirys than in chemiſtry, has wrote a very large treatiſe to ſhew that an acid ſalt may be obtained from animals; but the acid he means is no other than the ſpirit of this ſea-ſalt, contained in the urine, and raiſed by a ſtrong fire. And that a ſtrong acid ſpirit may be gained in this manner from it,

*The doctrine it leads to.*

* Mr. *Boyle* has many curious obſervations relating to this ſubject, in his ſurprizing little piece called *Aerial Noctiluca.*

we shall see hereafter. *M. Homberg*, likewise, fell into the same error, in imagining he obtained an acid salt from human blood, by distilling it with its own dry *caput mortuum.* The fallacy of which experiment is manifest from hence, that the blood of any other animal that makes no use of sea-salt will not afford this acid. We, therefore, boldly assert, that there is neither acid, nor fixed alkaline salt, naturally contained in the bodies of any animals whatsoever; which must therefore be endued with the power of converting all kinds of salt, except sea-salt, into such as are of a volatile alkaline nature, or capable of being easily made so.

*Its use in medicine.* 3. It appears not improbable from what is here laid down, that the matter of the stone in the bladder may reside in the spirit of putrefied urine; which, tho clear at first, is yet full of salt, and by degrees changes to a yellow colour, shoots into crystals, and lets fall a red terrestrial substance, very like gravel, or the matter of the human *calculus*; which will again be taken up by the spirit upon a fresh rectification. Whence it may be conjectured, that a dissolvent for the stone is really contained in the urine it self, which forms it. And doubtless the matter of the stone was once a part of the urine; and perhaps of its salts, which appear rather to generate than dissolve the stone in the bladder. Sea-salt, without dispute, will in a great measure prevent the generation thereof; but not absolutely preserve the body from it, as *Helmont* imagined. If urine be mixed with sea-salt, nitre, vitriol, *&c.* the several parcels will, in time, deposite a stony matter; but that the least, to which the sea-salt was added. From whence it should seem, that if any salt could prevent the generation of the stone, it would be marine salt.

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## Chemical History *of SAL-AMMONIAC; a Preparation from* Urine.

### PROCESS XC.

*Exhibiting the production of* SAL-AMMONIAC, *by digesting and boiling* Urine *with sea-salt and soot.*

*The process.* 1. *To ten parts of the urine of any sound animal that drinks but little, discharged at the distance of twenty hours from feeding, add two parts of sea-salt, and one of wood-soot; digest them together for a considerable time in a warm place; and afterwards gently distil the mixture in a glass retort, with a sand heat, till the remaining mass becomes almost dry; diminishing the fire towards the end of the operation, to keep the matter from subliming: then take*

*take out the remaining mass, beat it to powder, and sublime it in large vessels, with proper degrees of heat, into glebes, or lumps, which are called by the name of common* sal-ammoniac.

2. This is the common method of preparing sal-ammoniac, as practised in *Europe*, and particularly at *Venice*, as also in many parts of *Asia*, as *Alexandria*, *Cairo*, &c. where it is made in a large quantity, and to great advantage, because they there have plenty of animals, and particularly camels, which drink but very little; tho the same end may, in good measure, be answered by a longer digestion; wherein the urine acquires an alkaline nature, and the sea-salt is attenuated and grows acid; which thus form themselves into a third kind of compound salt, that in effect is sea-salt volatilized. In this process we are therefore to take the urine, which is the basis, for an alkali, and the acid of the sea-salt for the fixer, whereby a new semi-volatile, neutral salt is at length composed. The soot is added only on account of the copious, volatile, acid, or alkaline salt it contains; as we formerly saw in our processes upon vegetables, particularly those performed on *lignum vitæ*, and mustard-seed. *Its rationale.*

3. There are reckoned two kinds of sal-ammoniac, the natural and artificial. The artificial is that already described; and *Diascorides* gives us an account of the natural, which is found in *Lybia Cyrenaica*, near *Egypt*, in the place where the temple was built to *Jupiter Ammon*; from whence it is called *Sal Ammoniacus*, and by *Diascorides*, *Sal Cyrenaicus*. This temple was formerly very much frequented by strangers of all countries; who rode thither upon camels, a kind of animal remarkable for their long enduring of thirst. The truth is, they are wonderfully formed for making very long journies, without stopping to drink by the way; as being naturally provided of three or four receptacles near the stomach, with each its proper sphincter, in which they reserve part of the water they take down at once, to be ready, as their occasions, in passing over sandy desarts, shall require: for by this contrivance they have always something in readiness just to moisten their mouths withal; and as their drivers encourage this action in them, by rubbing their mouths with sea-salt three or four times in the day, they can very well pass three or four days without drinking. When thus, after a tedious journey, without any other opportunity of coming at water, these animals arrived at the temple; their urine, which they there plentifully discharged in the sand, being already, as it were, digested by the heat of their bodies, was farther concocted by the rays of the sun, and made to shoot into saline glebes, or lumps; which being afterwards found in this place by future pilgrims, they called it *sal-ammoniac*. So that in reality, this is not a native, as it has been supposed, but rather an artificial salt, prepared much after the manner of our present process. And this account of the thing is fully confirmed from hence, that the like salt is found in stables or stalls of camels; but not at all near the spot where the famous temple stood, since it has ceased to be so much fre- *Its similitude with the natural operation.*

quented on religious accounts. But how it should happen that sal-ammoniac is at this day likewise found near vulcano's, or burning mountains, such as *Ætna* and *Vesuvius*, after their eruption, is not so easy to say. This is certain, that upon examination, the salt found in such places, and sometimes under-ground, appears to be entirely of the same nature with that of our present process.

*Medicinal uses of the preparation.* 4. Sal-ammoniac, by being dissolved in water, boiled, skimmed, filtred, evaporated to a pellicle, and set to shoot in large vessels, will be converted into a pure white salt *, of a most subtile, penetrating, and stimulating nature, capable of passing thro' all the viscera and canals of the body, the nerves alone excepted; and powerfully resisting putrefaction in the body. This salt wonderfully mixes with the animal fluids, and becomes apperitive, sudorific, and perspirative: on which account it is famed for an admirable febrifuge; and being given before the fit, in the quantity of a dram, or four scruples, for a dose, dissolved in water or wine, it surprizingly cures quartan agues, in such constitutions as are free from scirrhosities, and a hectic; otherwise it commonly increases the distemper. Indeed it is an excellent medicine both in acute and chronical diseases; being a benign salt, much gentler in its operation than fossil salts, and nearly of kin to that of our own bodies; but not tending at all to an alkaline nature, and moderately dissolving the blood. *Galen* has well observed of it, that, being of a less specific gravity than sea-salt, it dilutes the blood without raising any violent commotions therein; for which reason it may be exhibited to greater advantage in many diseases, where the body cannot bear to be disturbed. Whilst it dissolves in water, it gives an intense degree of cold thereto, and little inferior to that of ice itself: so that any liquors plunged in the solution, may be rendered extreme cool, and potable with pleasure, in the violent heat of summer.

## PROCESS XCI.

### *Shewing that* SAL-AMMONIAC *is neither acid nor alkaline.*

*The process.* 1. *TO a quantity of sal-ammoniac dissolved in fair water, pour any strong, acid liquor, and no signs of effervescence will appear. Then to another parcel of the same solution, add the strongest alkali, whether fixed or volatile, and still there will no motion or ebullition be made; but the salt, which before was scentless, will now in an instant exhale a sharp, volatile, alkaline, caustic vapor, like that of putrefied urine.*

*Its use.* 2. It is somewhat strange in this experiment, that the sal-ammoniac, tho composed both of alkaline and acid parts, should afford no signs of either. Urine, left to it self, we know would putrefy; but when formed into this kind of salt, it neither putrefies nor appears so much

* This is the common method of purifying *sal-ammoniac.*

as alkaline; which is an instance of the virtue that sea-salt has of preserving the animal fluids from corruption.

## PROCESS XCII.

*Shewing the method of purifying* SAL-AMMONIAC *by* sublimation; *in which the flowers turn neither alkaline nor acid, but still retain the nature of that salt.*

1. *GRIND a proper quantity of well dried sal-ammoniac to fine powder, put it into a low cucurbit, with a wide mouth, and lute on a suitable head, in the common manner: bury the glass in a sand-furnace, almost up to the head; and gradually increase the heat to the highest that can be given in sand, and all the salt will rise in white fumes, and fix it self, like snow, in a white glebe, to the sides of the head, except a small quantity of grey or blackish feculent matter, that remains at the bottom of the cucurbit; by which means the salt will receive no manner of change in its nature, as to acid or alkali, but only be made more pure and penetrative.* *The process.*

2. Hence we see that sal-ammoniac is of a nature between fixed and volatile; being almost totally sublimable by a strong heat, tho not capable of being raised by a small one. And 'tis very remarkable, that in this process it is not analyzed, nor suffers any division of its parts; but rises again entire into salt, without affording any oil or spirit, or becoming of an alkaline nature. And this last property is what alone distinguishes it from the genuine animal salts, which constantly turn alkaline by the action of the fire; whereas, tho sal-ammoniac were sublimed a thousand times over, it would gradually become more pure and penetrative indeed, yet never of an alkaline nature; but, notwithstanding its being totally volatile or sublimable, remain the same unchanged sal-ammoniac it was at first. And this has occasioned the chemists to call it *Aquila alba*, the white eagle, in allusion to the bird which carried *Ganymede* up to *Jove*; its wings, to speak in their language, that is its particles, which rise in sublimation, carrying up the particles of any other bodies, and even such as are metalline, mixed along with it. 'Tis likewise termed the hand or pestle of the chemists; because it subtilizes, or grinds, the parts of the bodies sublimed therewith; as appears evidently in *Lapis Hæmatites*, which is ground exceeding fine, or reduced to flowers, by undergoing this operation along with it. And if even gold, the calx of vitriol, tho ever so long calcined, or the most fixed bodies in nature, be ground with this salt, it will presently render them volatile in the fire, and make them sublime; and hath this good quality belonging to it, that, being neither acid nor alkaline, it may easily be separated or washed away from any of those bodies that are sublimed along with it. The character whereby the chemists generally denote it, is such as exactly expresses the figure of its crystals, thus ⁕. *Its uses.*

## PROCESS XCIII.

*Exhibiting the manner of obtaining a moſt fiery, volatile and penetrating* Spirit *from* SAL-AMMONIAC *mixed with quick-lime.*

*The proceſs.* 1. T*AKE equal parts of the flowers of ſal-ammoniac, the production of the preceding proceſs, and good ſtone quick-lime; and in a dry mortar, and dry air, ſpeedily grind them ſeparate to fine powder, then preſently mix them together; and at that inſtant the moſt fiery, volatile, cauſtic, and piercing vapour hitherto known will fly off from the mixture; being exceedingly like to that which riſes from the mixture of inſpiſſated urine and quick-lime.* (2.) *If this mixture be directly diſtill'd, with a proper addition of water, in a well luted retort and receiver, by ſlow degrees of fire, it will yield a wonderfully ſharp and volatile liquor, which, tho violently cauſtic, is ſcarce at all of an alkaline nature.* (3.) *The remainder, after diſtillation, being put into a crucible, and detained in an open fire till it melts, may afterwards be run into glebes, and preſerved as a kind of phoſphorus; for it will ſhine in the dark, and afford ſparks of fire by percuſſion. But it muſt be kept from the air, to make it continue fit to afford this phænomenon.*

*Uſe of the production.* 2. The ſubtile ſpirit, obtained by this proceſs, proves violently pungent and ſtimulating to the nerves; for which reaſon it is very uſeful in all lethargic, apoplectic, or epileptic caſes, or where the ſpirits are to be ſuddenly rouzed or recalled; but it is always to be employed with the greateſt caution; for if a perſon, not affected in this manner, were to draw the vapour of this ſpirit at his noſtrils, it would inſtantly ſtrike him to the ground, like thunder; and either ſuffocate him, or by ſeizing upon and corroding the tender membrane, or veſſels of the lungs, ſuddenly cauſe a peripneumonia, or elſe an inveterate cough for life.

## PROCESS XCIV.

*Shewing that a* fiery Spirit, *and a volatile* alkaline Salt *are obtainable from* SAL-AMMONIAC *by means of fixed alkali.*

*The proceſs.* E*Xpeditiouſly grind equal parts of the flowers of ſal-ammoniac, and fixed alkali, or ſalt of tartar, ſeparately, to fine powder, in cloſe veſſels, without admitting any moiſture to come at them; afterwards mix them ſpeedily together; and from theſe two ſcentleſs bodies there will immediately ariſe a fiery, volatile, cauſtic, alkaline, and ſtrongly odorous vapour, like that which aroſe from the mixture of inſpiſſated urine and fixed alkali; and may, after the*

*ſame manner, be caught, and condenſed into a liquor by proper veſſels.* (2.) *The mixture being put into a cucurbit, and diſtilled very carefully and artificially, with a large and well luted receiver, in a ſand-heat, there will aſcend a dry, white, or wonderfully volatile ſalt, in appearance like to the flowers of ſal-ammoniac, but violently cauſtic and alkaline.* (3.) *If a quantity of water, equal to that of the ſal-ammoniac, be added to the mixture, and the proceſs carried on as above-mentioned, there will ariſe a dry, volatile ſalt; which, as the operation is continued, will, tho it be a pure ſalt, without earth, oil, or acid, be diſſolved down in veins, like oil, by the ſubſequent phlegm, into a liquor commonly called* alkaline ſpirit of ſal-ammoniac.

2. The ſalt obtained in this proceſs, is ſo exceedingly volatile and penetrative, that it is ſcarce poſſible to keep it in a glaſs, tho ever ſo cloſely ſtopped with cork and bladder; nothing but a glaſs ſtopple being able to withſtand it. It will every grain exhale inſenſibly away thro' the leaſt imaginable crack or vent; or, if the air gets at it, immediately melt in the veſſel. It is ſo violent a cauſtic, that if applied to the skin, and covered with a bladder to prevent its being ſuddenly exhaled by the heat of the body, it will, in the ſpace of a minute, eat into and mortify the part. If, upon occaſion, it be deſired ſtill ſtronger, it may be made entirely of an igneous and perfectly cauſtic nature, by ſubliming it once or twice with freſh ſalt of tartar; by which means it may be made ſo ſtrong, as inſtantly to deſtroy a man by its ſcent: for its vapour thus ſeems perfectly to condenſe or ſqueeze the lungs together, ſo as to hinder their expanſion, and render their recovery difficult even by the uſe of the ſtrongeſt ſpirit of vinegar. And for this reaſon, its vapor is to be very cautiouſly avoided in the preparation. *Uſe of the preparation.*

## PROCESS XCV.

### *Exhibiting the preparation of* Sylvius's Febrifuge Salt, *from the* remains *of the preceding proceſs; or the regeneration of* Sea-Salt *from* SAL-AMMONIAC.

1. *WHEN all that is volatile in the ſubject of the preceding proceſs, has been driven over by the violence of the ſand-heat, a dry maſs of a fixed ſalt will remain at the bottom of the glaſs; which being put into a crucible, fuſed in an open fire, diſſolved in water, filtred, evaporated to a pellicle, and ſet in a cool cellar to ſhoot, will afford cryſtals of a cubical figure, having the pungent taſte, fixedneſs, and colour of ſea-ſalt, as alſo the power of diſſolving gold, when mixed with* Aqua fortis *or ſpirit of nitre; that is, cryſtals of genuine ſea-ſalt.* *The proceſs.*

2. The ſea-ſalt thus regenerated, is called by the name of *Sylvius*'s *febrifuge ſalt*, becauſe he is ſaid to have uſed it, as a ſecret, with great ſucceſs in the cure of intermitting fevers; and for that purpoſe, preferred it to all other ſalts. His method was to give it in the quantity *Medicinal uſe of the production.*

tity of fifteen or twenty grains for a doſe, diſſolved in carduus-water, two hours before the time of the fit, in order to prevent it by ſweat, or to break away the febrile coagulum in the blood. But however he might eſteem it, 'tis certain that ſal-ammoniac, or its flowers, are a much better medicine to anſwer the ſame end: nor do I know a more effectual remedy than about twenty grains thereof, given in a draught of hot wine, or other convenient warm liquor, an hour or two before the fit is expected, for the cure of tertian and quartan agues. A ſingle doſe will commonly put by the former, and three or four will finiſh the cure of the latter; provided the patient be not of a cachectic habit of body. This is likewiſe a more valuable and certain medicine than that powder which has been ſold at a high price for a febrifuge, conſiſting of *antimonium diaphoreticum*, and the regenerated ſea-ſalt of our preſent proceſs.

*Phyſical and chemical uſes of the proceſs.*

3. We learn from the preceding proceſſes, that ſal-ammoniac conſiſts of a volatile, animal alkali, fixed by the volatile acid of ſea-ſalt. But as fixed alkali attracts acid more ſtrongly than it does volatile alkali, if fixed alkali be mixed with ſal-ammoniac, it will draw to it ſelf the acid of the ſea-ſalt, from the weaker animal alkali; which being then deprived of its fixing acid, will be left purely urinous and volatile. Upon this, all that is volatile being driven away, it is evident that the fixed alkali, now ſaturated with the acid, muſt remain behind, poſſeſſed of the fixedneſs and other properties of ſea-ſalt; that is, the ſea-ſalt of the compoſition will be regenerated: and thus the ſpirit of ſea-ſalt, and the ſpirit of urine mixed together, in ſuch a proportion that each ſhall be ſaturated with the other, will conſtantly make a ſal-ammoniac. Whence we are taught the nature and origin of volatile alkaline ſalt; the method of producing it; of fixing it when produced; and again of ſetting it free and making it volatile. Upon the whole, it appears, that there is a very great ſimilitude between ſal-ammoniac and the ſalts of the human body; the principal difference being only this, that the latter readily turn of an alkaline nature, by the firſt impreſſion of the fire; whilſt the other, as was before obſerved, obſtinately remains the ſame, after repeated ſublimations; both of them in other reſpects, as particularly in diſtillation with fixed alkalies, &c. exhibiting the like phænomena.

CHE-

# Chemical History *of the* WHITE *of* EGGS.

*Introduction to the history of the white of eggs.*

THAT we might have a juſt chemical hiſtory of the animal kingdom, it was neceſſary firſt to examine that fluid which begins to receive an animal nature, without having perfectly attained thereto; and this, we ſaw was milk. In the next place, we were to make our experiments upon that animal liquor, which, by having undergone repeated circulations in the body, was arriv'd at a perfect animal ſtate; but which, if long detained in the body, would become noxious, or prejudicial thereto. It is now in the third place, incumbent on us, to inquire into the nature of thoſe juices which are not only moſt completely animal, but ſo wholeſom, as that they may ſafely be detain'd in the body, and conſtitute the parts thereof, without prejudice to any of the faculties, whether animal, vital or natural: and this is an inquiry of ſingular ſervice to let us into the knowledge of animal nature. We are, therefore, next to find, for the object of our ſucceeding experiments, ſuch a perfect animal fluid as is no way excrementitious, but may be ſeparately collected without any heterogeneous parts, and certainly known to afford the matter for the formation of all the parts of animal bodies, both liquid and ſolid. And this fluid we have from the oviparous claſs; it being no other than the white, or pellucid part of the egg wherein the yolk appears to ſwim. All the parts of a chick, as the blood, fleſh, bones, *&c.* are form'd out of the bare white of the egg; for nothing but this is conſumed during the time of the incubation of the hen: the yolk all the while remaining entire, and ſerving as the *placenta*, which appears to be vaſcular, or to conſiſt of a number of veſſels, to prepare the white, and make it a fit nutriment for the body of the chick. It is, therefore, an elaborate, and abſolutely finiſh'd liquor, wonderfully deſign'd by nature to compoſe all the different organs of the oviparous tribe of animals: ſo that in order chemically to diſcover the nature of animal bodies, we cannot have a more proper ſubject for our experiments than this liquor, which is wholly convertible into their ſubſtance, except that ſingle point, or ſpeck thereof, which proceding from the male, lays the firſt rudiments of the fœtus, and without which no young is ever excluded. By the examination of our ſenſes, the white of eggs appears to be a viſcous, mild, unactive, inſipid, inodorous liquor, capable of mixing with water; but incapable of cauſing pain to any part of the body, even the eye it ſelf.

PRO-

## PROCESS XCVI.

### *Shewing that the* WHITE *of* EGGS *is neither alkaline nor acid.*

*The process.* 1. *LET fall any proportion of a known acid, as oil of vitriol,* &c. *tho ever so strong, upon the white of an egg, contain'd in a proper glass, and it will cause no effervescence or ebullition therewith; and consequently, it is no alkali. Upon another parcel of the white, let fall any quantity of a known alkali, as oil of tartar* per deliquium, *and this likewise will cause no ebullition; consequently the white is not an acid. Nor will it manifest any signs of either, by the other known experiments allowed to distinguish acids and alkalies.*

*Its effects.* 2. The oil of vitriol indeed will cause the white of the egg to appear of a somewhat thicker consistence than it did before; and the same will happen in the blood and its serum; tho without the least effervescence. But if these animal fluids were either acid or alkaline, so far as, by the mixture of their opposites, to cause such an ebullition in animals, as would, for instance, be made by mixing two different parcels of the liquors of our present process together, their bodies would be burst to pieces with the force.

## PROCESS XCVII.

### *Shewing that the recent* WHITE *of* EGGS *dissolves with a gentle heat, but concretes with a stronger.*

*The process.* 1. *PLACE the white of a new-laid egg in a very gentle heat, scarce exceeding that of a healthy human body, and it will gradually grow thinner and thinner, till at length it totally liquifies, and becomes almost like urine.* (2.) *Expose the white of another fresh egg to twice the former heat, or one equal to that of boiling water, and it will immediately, without any considerable exhalation, be hardned or concreted into a white, opake, dry, viscous, fissil mass, inodorous, insipid, and not without difficulty to be resolv'd again.*

*Its use in natural philosophy.* (2.) When a hen sits upon an egg incapable of affording a chick, the heat of her body, which is much the same with that here first made use of, gradually liquifies the internal part thereof, and turns it to a fluor, which at length becomes of a putrid nature, like digested urine; whilst, on the other hand, the same degree of heat, gradually dissolves down the white of a prolific egg into fit nourishment for the chick. But if the heat were considerably greater, we see by our present process, that this effect would not be produced; for the white would then be concreted, and become incapable of nourishing the embryo. And that this alteration in the consistence of the white of the egg cannot be owing to any evaporation of its humid parts, is plain from hence, that the same thing would immediately happen,

pen, if the egg were plunged entire, with its ſhell, or only the white, into boiling water; and this is likewiſe the caſe of the ſerum of the blood, and other juices of the human body.

3. Here we are taught, that there is a ſurprizing difference, as to the effect, between the action of different degrees of heat, upon the ſame animal liquor; and no leſs than that of fluidity and firmneſs: whence it is eaſy to account for the good effects produced by the application of warm cataplaſms, or fomentations in tumors and other caſes of chirurgery; and for their bad ones, when they are apply'd too hot to the part. Warm fomentations may diſcuſs and reſolve the concreted or coagulated juices; but ſuch as are ſcalding hot, may eaſily confirm the tumor, or, if ſeated in a glandulous part, turn it ſchirrous; that is, into a ſubſtance that will not eaſily putrefy or diſſolve. Water that is made a little hotter than the blood of perſons in a fever, will ſoon thicken the ſerum and other animal fluids, and make them concrete. And it is certain, that a violent degree of heat is very pernicious to the human body; as occaſioning grievous obſtructions or polypus's therein: And of this we have daily inſtances in the blood of thoſe who labour under any inflammatory, or hot diſtemper: ſo that their opinion is the direct contrary to truth, who aſſert, as ſome phyſicians do, that heat, in general, reſolves and attenuates the animal juices; whereas any conſiderable degree thereof will certainly thicken, and make them viſcid. And thus, tho it be generally ſuppoſed that hot water dilutes and thins the animal fluids; yet, if it be drank more than blood-warm, the truth of the aſſertion may juſtly be queſtioned. *Its uſe in medicine.*

## PROCESS XCVIII.

### *Shewing that the recent* WHITE *of* EGGS *is concreſcible in alcohol.*

1. *PUT the crude and liquid white of a new-laid egg into a quantity of pure alcohol of wine, in the cold, and it will immediately concrete, or coagulate, as by the heat of the fire, or boiling water; the coagulation of the parts proving the ſtronger, the more intimately the alcohol is mixed with the white: and thus it may long be preſerved in a ſtate of incorruption.* *The proceſs.*

2. Here we learn the natural effects of a fine, vegetable oil, upon the matter whereof all the parts of an animal body may be form'd; whence we may ſee, how it comes to paſs, that ſpirit of wine is ſuch an immediate ſtyptic, and anodyne, as we find it in caſe of hæmorrhages, and punctured nerves; why pure wine uſed by way of fomentation has the power of diſcuſſing tumors, whereas pure alcohol would make them ſchirrous; why alcohol injected into the veins is ſudden death; and whence it happens, that being drank, it is obſerved by medicinal writers to have been of the nature of poiſon, and proved ſpeedily mortal. For thus it coagulates the blood and other animal juices, and inſtantly cauſes *Its medicinal uſe.*

obſtructions

obstructions in the vessels of the body. Those physicians then are greatly mistaken, who take pure alcohol for an attenuating and resolving liquor, that volatilizes all the animal fluids, and renders them the more perspirable. On the contrary, it is frequently found to harden and condense them, as appears particularly in the case of swell'd and indurated breasts; which being fomented with spirit of wine, or *Hungary* water, in hopes of resolving the tumor, thereby become more hard, and cancerous.

## PROCESS XCIX.

*Shewing that the water gained from the* WHITE *of recent* EGGS, *by gentle* distillation, *is neither acid, nor alkaline.*

*The process.* 1. BOil *a sufficient quantity of the white of fresh-laid eggs, in water, to a hard consistence; then commit it to a retort, placed* in balneo mariæ: *gently distil it till it becomes almost dry; and there will come over a very large proportion of a volatile water, that has scarce any scent or taste, unless it inclines a little to fetid and sulphureous; and neither of an inflammable or spirituous, an acid, or an alkaline nature, as will appear upon the proper trials.*

*Confirmed; with its use.* 2. If the white of eggs, after it is boiled, be suffered to remain for any considerable time, even in the open air, without heat, it will distil, or again resolve as it were, and suffer a very great diminution in its quantity, so as at length to appear in the form of a thin pellicle, almost like paper; and if the water be collected in proper vessels, it becomes an admirable solvent for bodies otherwise very hard to dissolve; so that even gum-hedera, or the like substances, are by means thereof easily reduced to an oil. Hence it is manifest, that the salt, spirit, and oil are more fixed in the white of eggs, than the phlegm or water; which appearing upon examination to contain no latent alkaline, or acid salt, we may fairly conclude, that the fluid whereof all the parts of an animal body may be composed, has naturally nothing in it that can be called of an alkaline or acid nature.

## PROCESS C.

*Shewing that the* WHITE *of* EGGS, *by a strong* distillation, *affords an alkaline spirit, and salt, two kinds of oil, and an earth.*

*The process.* 1. IF *the remains of the preceding process be urged with proper degrees of fire in a sand-furnace, there will first arise a yellowish spirit, which by rectification affords a large proportion of dry, white, volatile, alkaline salt. Upon*

*increasing the heat, there will ascend a copious, alkaline salt, together with a light, fetid, gold-coloured oil; and lastly, with a violent heat, one that is gross, thick, black, and strongly fetid; a light, black, spongy earth remaining at the bottom of the retort, and, by calcination, in an open fire, affording no fixed salt, but becoming white and insipid; tho it can never, by any art, be perfectly freed from its oil.*

2. Hence we learn what surprizing alterations different degrees of heat can bring upon the subject matter of animals; and may conclude, that volatile salts never, in their own form, naturally exist in animal bodies, whilst they enjoy a state of health; and that the heat required to render them volatile would first destroy the body. *Its use.*

## PROCESS CI.

### *Shewing that the* WHITE *of* EGGS *will putrefy by digestion, and turn alkaline.*

1. PUT *a quantity of the white of recent eggs into a tall glass, and, with a gentle heat, not exceeding that of a healthy man, digest it for a few days, and it will gradually become more fluid and transparent, and afterwards begin to smell fetid and alkaline, till, at length, it will not coagulate at the fire, but make an effervescence with acids, exactly like putrefied urine; and if it be now distilled, it first affords an alkaline, volatile, spirit, instead of the insipid water it would yield before digestion; and if the operation be continued, it will proceed in every respect as the distillation of digested urine.* *The process.*

2. A single grain, or even half that quantity of this putrefied substance, being taken into the body, will, like the strongest poison, presently cause a violent nausea, vomiting, and eructations, a fever, a diarrhœa, *&c.* as *Bellini* tells us he has tried. And I my self have more than once seen it given, without the knowledge of the person who took it; and then also it has had these terrible effects: which, however, are immediately stopped by drinking any acid liquor, as vinegar, the juice of lemmons, *&c.* Even the scent thereof may, by a longer digestion, be made to do the same. Having once continued the operation for the space of eight days, and then coming to handle the glass, I was immediately seized with a very violent nausea, vertigo, horror, anorexia, *&c.* And hence we may readily account for the origin of abundance of diseases. Thus, for instance, it is no wonder if the bile, by stagnating, as it sometimes does, that is, by digesting in the warm human body, receives such a change as to produce the *cholera morbus*, with the nausea, vomiting, and other grievous symptoms wherewith it is sometimes attended. The salts of animal bodies, however, never become of an alkaline, or pernicious nature, but by heat, digestion, stagnation, or putrefaction; which latter is the consequence of stagnation, and never happens without it: but when once they turn volatile, or alkaline, the life of the *Its use.*

the patient is immediately endangered, by a gangrene, mortification, apoplexy, or the like. And whether the plague, the symptoms whereof succeed each other so fast, be not owing to some such cause as this, is a proper subject of inquiry for physicians.

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## CHEMICAL HISTORY *of the* SERUM *of the* BLOOD.

*Introduction to the history of the serum of the blood.*

THE next animal fluid to be chose for the subject of our examination, is that which we know, by certain experiments, made in the physiological part of medicine, to be the sole, nutrimental matter of a healthy human body, which repairs the daily waste of all its parts. And this is no other than the serum of the blood; or to speak more accurately, some very subtile liquor separated from it; which not being obtainable, we take the *serum* it self. There can no doubt be made, that the body is supplied and nourished by means of the fluids which flow thro' all its vessels; but the *crassamentum*, or red part of the blood, flows thro' no other vessels than the larger veins and arteries; whilst the *serum* passes not only thro' the same, but likewise thro' the lymphatics, and the smallest canals, wherein the action of nutrition is required.

### PROCESS CII.

*Shewing that the* SERUM *of the* BLOOD *is neither acid nor alkaline.*

*The process.*

1. *TO a proper quantity of the clear serum of human blood, add any the strongest acid, and it will make no manner of effervescence therewith, but lie perfectly quiet, or without visible motion. To another parcel of the same serum, pour any the strongest alkali, and in like manner no signs of ebullition will appear. Whence it is certain, that the serum of human blood naturally participates neither of an acid or alkaline nature.*

*Confirmed and applied.*

2. In like manner, if all the chemical methods of examining alkalies and acids were applied to the serum of human blood, they would never discover the least sign of either therein. But when the serum is fresh extracted, it has somewhat of a nauseous yet not fetid odour, like the scent of recent urine; and this is the natural smell of the fluids of our bodies, when in their most pure and uncorrupted state. When that violent acid, oil of vitriol, is added thereto, it becomes thicker and

whiter;

whiter; but oil of tartar dilutes or thins it, yet without exciting the leaſt conflict therewith; tho when the two different mixtures are put together, a violent one will immediately be raiſed. In its natural and perfect ſtate, it is a tranſparent, viſcous, uniform, and almoſt inſipid fluid, nearly reſembling the white of eggs; bating for its being ſomething ſaline, on account of the ſea-ſalt uſed by mankind along with their aliment. If it was really an acid, as *Sylvius* pretended, and by mixing with the alkaline blood, as he conceited it did, to keep up its circulation; the oppoſite ſalts thereof muſt upon ſuch mixture raiſe a ſtrong ebullition, and efferveſſence in the body; and ſo produce either violent tumors, or a rupture of the finer veſſels, whereby life it ſelf would immediately be endangered. And for this reaſon, we may ſafely reject his hypotheſis, together with thoſe of *Willis* and *des Cartes*, who feign'd ſuch kind of efferveſcences in the animal body, to account for the phænomena therein. But it may be objected againſt our preſent experiment, that altho the ſerum which has long been extracted from the body, and ſuffered to grow cool, may manifeſt no ſigns either of a latent alkali, or acid contained therein; yet it may nevertheleſs contain them, whilſt hot and circulating in the body. To obviate this objection, I have made a vaſt number of experiments, with the known acids and alkalies upon the blood of different perſons, of different ages, and the different ſexes, ſome of them labouring under fevers, or other diſeaſes, as it came warm from the vein; but could never obſerve the leaſt marks of any efferveſcence, or conflict.

## PROCESS CIII.

### *Shewing that the* SERUM *of the* BLOOD *will putrefy by digeſtion.*

1. *PUT any quantity of the clear ſerum of healthy human blood into a cloſe, tall glaſs, and ſet it to digeſt in a moderate heat, not exceeding that of the body in a ſtate of health, and it will gradually become thinner, and ſoon begin to ſmell cadaverous, and putrefy; ſo that at length, in a few days time, it will, like the white of eggs, turn to a perfectly alkaline ichor, and make a violent efferveſcence with acids; and if now committed to diſtillation, it immediately affords a quantity of alkaline ſalt,* &c. *exactly like the digeſted white of eggs.* *The proceſs.*

2. If the digeſtion ſhould be long continued, as for the ſpace of ſeveral days, the matter, or its oil, might be thereby rendered ſo intolerably fetid, as to make the operation dangerous; for the bare ſcent thereof would then be capable of doing much miſchief, even at a diſtance. *Its effects, if continued.*

3. Hence we learn the effects of a gentle warmth upon the blood; and ſee that this is a proper means to reſolve it, when coagulated; and by making it finer, to render it fit to paſs the ſmaller canals of the body, *Its uſe in medicine.*

 where

where it would otherwise not enter at all, or cause obstructions. And this process alone will help us to cure and account for many diseases of the human body. Thus the viscous matter which lies like leather upon the extravasated blood of pleuritic persons, may by a gentle heat be almost wholly resolved again into serum: whereas if it should retain its tenacity whilst it was flowing in the vessels, it would cause obstructions, and be still more condensed therein. So, likewise, in all inflammatory distempers, to keep the body moderately warm is the way to thin the fluids, and hasten the crisis, or the discharge of the morbific matter, by encouraging or promoting some evacuation or other. But when the blood comes to be extravasated, and stagnates in any part of the body, suppose in the cavity of the thorax, or abdomen; being now no longer agitated by the force of circulation, it will first coagulate, then soon begin to resolve, and at length putrefy, and become alkaline, sharp, and corrosive; whence, if lodged in the cavity of the thorax, it might bring on a phthisis, by fretting away the tender substance of the lungs, or cause the empyema; or if in the abdomen, destroy the texture of the lymphatic vessels, whence they will distil out their liquor, and form the ascites. And after this manner may numberless other distempers be produced.

## PROCESS CIV.

### *Shewing that the* SERUM *of* HUMAN BLOOD *is concrescible with a greater heat.*

*The process.* 1. *LET a quantity of the recent serum of healthy human blood be received in a clean glass vessel, and exposed to a degree of heat somewhat greater than that it sustained in the body; then, without any considerable exhalation of its thin, aqueous part, or insipid water, it will immediately lose of its transparency, and form it self into a yellowish, viscous, membranaceous, fissil glebe, somewhat like horn, or parchment, not easily resolvable again, either by water, or salts.*

*Varied.* 2. This experiment will also succeed, like that made with the white of eggs, if the serum be put into hot water; for by this means, it will be converted into such a mass as that above-mention'd: which shews that it does not coagulate for want of its aqueous parts: but if once it has been digested or suffered putrefaction, it will no longer concrete, either by means of a dry heat, or a moist one. And, accordingly, it has been found, that the blood of such persons as have died of the plague, could not be made to concrete at the fire, on account of the putrefaction which was then, perhaps, begun in the body. But, if on the other hand the serum for our experiment be extracted from a person soon after any violent exercise, it will coagulate much sooner than if it had been obtain'd from a person of a weak, hydropical constitution.

3. Hence

3. Hence we see the great affinity there is between the serum of the blood, and the white of eggs; as likewise the effects producible by fire upon the human body. And as an increased heat has the power of instantly coagulating the animal fluids; it is a present and effectual remedy in case of the bite of a mad-dog, or other venomous animal, immediately to burn the part with a hot iron, applied, or rather thrust deep into the wound. For, by this means the juices about the part being coagulated, and an eschar produced, all communication of the poison to any other vessels is stopp'd; and thus the cure may be readily effected: not that the hot iron draws out the poison, as is vulgarly imagined; but renders the parts incapable of being penetrated or affected thereby. And hence it is, that the pain occasioned by burns, may be lessened, or taken off by a fire, or a greater degree of heat than that which made them; for this will coagulate the juices about the part, and thereby render it less sensible of the pain. Thus a violent degree of heat, we see, destroys the parts of the body, or coagulates its juices; whilst a less dissolves and turns them into ichor. And the like effect will be produced by motion, attrition, or an increased velocity of the blood and juices, as well as by direct heat. *Its use in medicine.*

## PROCESS CV.

### *Shewing that the* SERUM *of* HUMAN BLOOD *is coagulable with alcohol.*

1. *MIX a quantity of fresh serum of human blood with cold alcohol of wine, and it will instantly coagulate into a white, membranaceous, fissil mass, very difficult to be resolved again, and capable, in that state, of resisting putrefaction for many ages.* *The process.*

2. In like manner, if the serum, or blood it self, be digested, tho ever so long, with pure alcohol, it will not become fetid, nor shew any signs of corruption; for neither will its salts turn alkaline, nor its oils putrefy: which indeed is very surprizing. I have my self digested them together for the space of six months, and found them of a grateful odour at the end of that time: and this may serve to shew us what a wonderful balsamic virtue there is in alcohol, which is plainly owing to its coagulating principle. And on this account it is, that those who are given to drink too freely of brandies, or spirituous liquors, are frequently affected with polypus's, or obstructions arising from the concretion of the blood in the larger vessels, the palpitation of the heart, the dropsy, dry crispy nerves, and other disorders of this kind, which prove generally mortal. Hence the wonderful effects of alcohol in sphacelations and spreading gangrenes; a most remarkable instance whereof occurs in the *German* transactions, where we find, that a very aged woman, at the *Hague*, having a violent gangrene, which spread from *Its physical and medicinal use.*

the middle of her foot, up one half of her leg; and the phyſicians declining to take it off by amputation, on account of her great age and infirmity; they ordered, to ſtop the growing evil, the part to be frequently fomented with rectified ſpirit of wine; which proved ſo ſucceſsful, that, to their ſurprize, it not only prevented the farther ſpreading of the gangrene, but even embalmed the black and mortified part, dry as it was, like mumy; upon which the woman recovered and lived for two years after, with her leg thus preſerved from farther alteration. And this relation may ſerve to ſhew, that gangrenes are not contagious, or of a ſpreading nature but by means of the ichor, or corrupted matter which comes in contact with the adjacent parts. Hence alſo we may learn, that nothing can well reſiſt the growth of animals more powerfully than alcohol; provided it be mixed with the ſerum, or that fluid which affords them their nutriment. And upon this is founded the method practiſed in *Italy*, and elſewhere, of procuring particular animals of a very little ſize. When they deſign this, they frequently rub the animal over with alcohol, or ſpirit of wine; which meeting with the nutritious juices in the extremities of the veſſels, there gradually thickens or coagulates it, and thus increaſes the reſiſtance of the ſurface againſt the force of the liquids, which would otherwiſe ſtretch out the veſſels farther, and ſo increaſe the bulk of the animal. But alcohol is not the only thing that will thus coagulate the blood; as we ſhall ſee hereafter.

## PROCESS CVI.

### *Shewing that the* SERUM *of the* BLOOD, *by gentle diſtillation, affords a water that is neither acid nor alkaline.*

*The proceſs.*

1. TAKE *the freſh and clear ſerum of healthy human blood, and diſtil in a low glaſs, with a very gentle heat, ſcarce exceeding that of the human body in its natural ſtate, and there will come over almoſt five ſixth parts of an exceeding limpid water; which if examined by all the known chemical trials, gives no ſigns of its being either of an acid or alkaline nature; nor indeed of containing any ſaline matter or inflammable ſpirit; a dry maſs remaining at the bottom of the receiver.*

*The doctrine it eſtabliſhes.*

2. Hence again we may be aſſured, that there are no volatile ſalts, or inflammable ſpirits, naturally contained in the blood; but that water, as it appears to be, is the moſt volatile part thereof. But if the ſerum ſhould participate of the nature of the chyle, as it poſſibly may in a lax or weak habit of body, where the natural powers are too feeble to effect a thorow change of the aliment; or if the chyle ſhould not be well mixed with, but remain floating upon the blood, the ſerum might perhaps afford an ardent ſpirit by diſtillation. But we here ſpeak only of perfect ſerum, taken from a ſound body, at a due diſtance of time after

feeding. It is alſo generally aſſerted, that the blood contains a copious volatile ſalt; but none can be made to aſcend from recent ſerum, by the gentle diſtillation of our preſent proceſs; tho it may be forced over the firſt in the following. We therefore venture to aſſert, that the moſt noble and moſt ſubtile part of the whole maſs of blood, is that which approaches nearer to the nature of water than of any other known liquor. This may ſeem a paradox, but experiments abundantly ſupport and confirm the truth thereof.

## PROCESS CVII.

*Shewing that the inſpiſſated* SERUM *of* HUMAN BLOOD *affords, by ſtrong diſtillation, a ſpirit, a volatile alkaline ſalt, two kinds of oil, and an earth.*

1. *A Sufficient quantity of the remainder of the preceding proceſs being obtained, and cut into ſmall pieces, ſo as to fill two thirds of a coated retort, gradually diſtil it in a ſtrong heat, and it will afford a large quantity of a yellow, unctuous liquor, called the ſpirit of human blood, and next a dry volatile ſalt that ſticks to the ſides of the receiver; then, upon increaſing the fire, a heavy ponderous oil will come over; all the lighter oil remaining mixed with the two other principles: here the operation is to ceaſe, otherwiſe great danger may enſue. And now there will be left at the bottom, a black, ſpongy kind of earth, mixed with oil; which being calcined in an open fire, affords no fixed ſalt, unleſs it be ſea-ſalt; all exactly in the ſame manner as in the analyſis of the white of eggs.* *The proceſs.*

2. The caution given in this proceſs ought to be carefully obſerv'd, as being a thing of the greateſt moment; tho no author has hitherto taken the leaſt notice thereof: for if after the ſpirit, ſalt, and oil of the ſerum are drawn off, the remaining maſs be urged with a ſtrong fire, it will fuſe like bitumen, riſe into the neck of the retort, block it up, and at length burſt the glaſſes with prodigious violence, into a thouſand pieces; at the ſame time filling the laboratory with a dreadful ſuffocating flame. Having once drawn off the ſpirit, ſalt and oil of human blood, in order to make *Helmont*'s quinteſſence thereof, and urging the remainder with a very ſtrong fire, to try if I could gain any phoſphorus from it, other buſineſs happened to call me away whilſt the operation was in hand; ſo that, at my return, I found a thick, brown, bituminous, or pitchy matter was riſen into the neck of the retort, and almoſt filled it; upon which I apprehended the enſuing danger, and immediately retired from the laboratory, waiting the event at ſome diſtance without doors; and in a little time the veſſels burſt to pieces with a horrid crack, and inſtantly the whole place where I ſtood was filled, as it were, with lightning. Then ruſhing immediately into the laboratory, the flame I found was preſently extinguiſh'd; which doubt- *The caution it requires.*

leſs,

leſs, might otherwiſe have ſcorched the lungs, and proved inſtantly mortal; but it left behind it a very noxious vapour, exceedingly corroſive to the lungs. To avoid this danger, therefore, it may, when there is occaſion to continue the proceſs, be proper to perform it with a very large retort and receiver, and a very ſmall quantity of blood, or ſerum. This caution ought by no means to have been omitted by thoſe authors who have mentioned the experiment.

*Its phyſical and medicinal uſes.* 3. From the preceding proceſſes it appears plainly, that there is a very great affinity and ſimilitude between the ſerum of the blood and the white of eggs; and that the ſerum is really the nutrimental matter of the body, tho not immediately, but remotely. The whole chick receives its nouriſhment and growth from the white of the egg; which is ſo attenuated and diſſolved down by the heat of the brooding hen, as readily to enter and paſs thro' the fine and delicate veſſels of its tender body. In like manner, the ſerum of the human blood is ſo attenuated by attrition, or repeated circulations, and the heat of the body, as to paſs thro' all its minuteſt canals, and become fit nutriment for it. But as by this continual circulatory motion, ſome particles of the ſerum will neceſſarily be ſo far attenuated as to become ſharp and offenſive to the body, nature has provided a particular organ, the kidneys, to diſcharge them, before they can have time to injure the curious ſtructure. Hence, therefore, we are given to underſtand the difference there is between the urine and the ſerum; and why the ſalt of the former is more fetid than that of the latter; the neceſſity there is of a new ſupply of chyle to the blood; and the immediate cauſe of death from a want of food, to furniſh new chyle, which is not required, upon its own account, by the body, but merely to repleniſh and dilute the blood, too much attenuated and rendered ſharp by repeated circulations; whence, inſtead of repairing the tender veſſels, it corrodes them: ſo that perſons in this ſtate commonly die apoplectic; the fine canals of the brain being firſt affected.

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## Chemical History *of the ANIMAL SOLIDS.*

*Introduction to the hiſtory of animal ſolids.* HAVING, in a few ſelect and general examples, ſeen the nature, analyſis, and principles of the animal fluids, our method next requires us to examine ſuch of the animal ſolids as are moſt ſimple, pure, dry, and clear of the mixture of any heterogeneous matter; ſuch are the bones, well freed of their fat, horns, hoofs, nails, hair, teeth, *&c.* And this we ſhall perform in one general example, which ſhews us the reſult of a larger number, ſeverally performed upon theſe particular parts of animals.

PRO-

## PROCESS CVIII.

### *Shewing that the principles of the* ANIMAL SOLIDS *are the same with those of the* animal fluids, *by an example in the analysis of human bones.*

1. F*ILL two thirds of a retort with small pieces of undistempered human bone, which to appearance has lost all its moisture, or is grown perfectly hard, solid, white and dry; lute a large receiver to the retort, in the common manner, and in a sand furnace apply proper degrees of fire successively, and there will come over first a very large proportion of an insipid water.* (2.) *Upon increasing the fire, white fumes will arise, and fill both the vessels, and trickle down in veins like oil, into a sharp, oily, alkaline spirit, which by rectification in a tall glass, may be separated into phlegm, volatile salt and oil.* (3.) *Afterwards, a yellow, or white, dry, volatile, fetid, sharp, oily salt, ascends, and sticks to the sides of the receiver; and by degrees turns of a reddish colour, according to the quantity of oil that is mixed along with it.* (4.) *A light, volatile, fetid, yellow, and very fluid oil, comes over next.* (5.) *And at length, the fire being increased to the height, a ponderous, fetid, black viscous oil, will arise, and generally fall to the bottom of the spirit, if left in the receiver.* (6.) *What now remains at the bottom, is a very black, shining matter, composed of oil and earth, intimately united together; which being calcined in an open fire, falls entirely into white, insipid ashes, without affording the least quantity of fixed salt; only a little sea-salt, when the person whose bone it was had used that along with his food.* *The process.*

2. The productions and phænomena of the process will be much the same, whatever animal solid is made choice of for its subject; but bones thorowly dried, or the hoofs and hair of animals, seeming to contain less blood, or fluid matter than the flesh, or other parts, are the most unexceptionable, and fittest for the purpose; there being the least suspicion, that the extremities, or hardest parts of the body, which seem almost destitute of vessels, should contain such a quantity of pure water as is obtained from them by such treatment. And even the dryest animal substances will resolve, as well as the blood it self, by distillation, and afford it; tho not in so great plenty as the more succulent and recent. Whence we have a very clear proof, that water may be intimately united with the parts even of dry solids, and greatly contribute to compose them. I have frequently distilled hartshorn, which had been kept dry for several years, yet at the end of that time it has afforded a very copious water: and this principle doubtless contributes greatly to the cohesion of the terrestrial parts of bodies, as may easily be inferred from the consideration of the matter whereof bricks are made; which tho well dried and baked in the kiln, still keep the form given it by the maker; but when by the continuance of a violent degree of heat, the water comes to be totally *Observations thereon; and the uses of its productions.*

exhaled, it presently falls to dust. After this water is once come over from the subject, a large quantity of fumes arise, which are of so subtile and penetrating a nature, that it is difficult for any lute to contain them in the vessels; whose insides they afterwards line with a copious alkaline, and exceeding volatile salt; so that if by rectification it be well purged of its oil; bladder and cork will not be able to keep it in the tightest glass. Once attempting to preserve of this salt by such means, in two years time I found the glass empty, yet to appearance firmly closed; the salt having all made its escape at the cork. I afterwards found the securest method to preserve this salt, was by keeping its oil along with it in a glass close stopped, and rectifying it as there was occasion. This indeed appears strange, and contrary to what one might reasonably expect, that the most solid, hard, inodorous and tasteless animal substances should contain, and so easily afford, large quantities of insipid water, and the most volatile and pungent salt. Care must be taken in this process, not to urge the remaining black, terrestrial matter with too strong a fire; for by that means it would, like the *caput mortuum* of human blood, be fused into a pitchy mass, block up the neck of the receiver, and burst the glasses, which might prove very dangerous to the operator. But if taken out in due time, or whilst it remains perfectly black and glossy, it may be properly called an animal coal; and is then an excellent remedy, of a very bitter taste, like all other adust oils, for destroying worms in the body; being taken fasting, in the quantity of about two scruples, or a dram, for a full grown person, mixed with a little hydromel, and walking after it. The same is also used as a pigment by painters, under the name of *bone-black*; for by continued grinding with oil, it becomes an admirable glossy black, for the purposes of their art. But when it comes to be calcined to white ashes, 'tis exceeding useful to assay-masters, and the purifiers of metals; as being capable of sustaining the most violent heat without fusing: of these ashes, therefore, reduced to impalpable powder, they chuse to make their tests and cupels; by mixing them up with a little water, and giving the composition what form they please. And by this means they obtain such vessels as will neither break, vitrify, nor any way foul the bodies committed to them, in fusion.

*General conclusions from the foregoing processes, with regard to natural philosophy and medicine.*

3. From the preceding processes we may draw this general conclusion, that urine, the white of eggs, serum, blood, flesh, bones, nails, hair, and all the particular animal fluids and solids, consist of and are resolvable into the same parts or principles. So that there is no foundation to expect specific or peculiar virtues in the water, spirits, salts, oils, or earths procurable by distillation from different animal subjects; for the native or presiding spirit, by the scent whereof it should seem that some dogs distinguish one kind of animal from another, appears to be lost in the operation. It is, therefore, the effect of fancy, more than the reasonableness of the thing, which occasions some authors to extol one particular volatile, animal salt, as a specific above all the rest. Thus some have

have been wonderfully fond of the volatile ſalt of hartſhorn; others of that of the human skull; and *Helmont* would have it, that the ſalt of human blood is a much more excellent medicine than that of urine. *Goddard*'s drops have been ſtrangely celebrated, and recommended as a ſpecific, tho diſtilled from nothing but that animal ſubſtance raw or refuſe ſilk, as it comes from the worm. But it appears by a thouſand experiments, that there is ſcarce any difference diſcoverable between the volatile ſalts of different animal matters, let what parts ſoever of the animals be made choice of for that purpoſe: and conſequently, the popular diſtinction made of animal ſalts into ſpecific and not ſpecific, is groundleſs and irrational; one being as efficacious and uſeful in any particular diſeaſe as another.

4. Nor are they only the animal ſolids and fluids themſelves in ſubſtance, that afford theſe principles by diſtillation; but alſo the ſeveral preparations made of either. Thus the gelly, for inſtance, made by a continued coction of lean fleſh, or purified bones, in clear water, is reſolvable into the ſame. Dry and ſolid hartſhorn, by diſtillation, affords a water, a ſpirit, a volatile ſalt, an oil, and an earth; but if it be boiled in ſeveral parcels of pure water, after the manner of our ſecond and third proceſs upon vegetables, till at length the water comes from it as pure and inſipid as when it was poured on, the remainder will yield no ſalt at all by diſtillation, and but very little oil. On the contrary, if the ſeveral decoctions be exhaled to a gelly, or a higher conſiſtence, and diſtilled, it will afford all the ſame principles with recent horn it ſelf, before it was boiled. And the ſame holds true of all animal ſubſtances, as fleſh, bones, and even ivory, or the like; tho perhaps the experiment cannot always be made to perfection without the aſſiſtance of *Papin*'s digeſtor for the decoction; and ſand, or other fit matter for the diſtillation.

5. Hence we ſee, that the baſis of animal bones is mere earth, cemented together by means of water, and an oil that is not without great difficulty entirely ſeparable from it. But when once it is deprived of this water and unctuous matter, it becomes like duſt, and is no longer capable of burning or receiving farther alteration from the fire; whence all that is purely ſolid in animal bodies ſeems to be of a very fixed and unchangeable nature. But if oil be added to this dry powder, or skeleton of a bone, it will preſently drink it in, grow hard again, and retain its form ſo long as the oil remains united with it. And hence, likewiſe, we learn the reaſon why bones that have long lain buried, or expoſed to the open air, will not by diſtillation afford the animal principles; *viz.* becauſe either by the moiſture of the ground they are attenuated and putrefied, or rendered volatile by the action of the air and ſun, ſo that they all fly off as in diſtillation, and leave nothing but aſhes or fixed earth behind. In the laſt place, we learn from our preſent proceſs, how it happens that fleſh

boiled too long will not afford proper nourishment to the body; whilst the decoction or gelly thereof becomes exceedingly nutrimental *.

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# CHEMICAL HISTORY *of the ANIMAL PRINCIPLES.*

## PROCESS CIX.

*Exhibiting the manner of separating, depurating, and rectifying the* ANIMAL PRINCIPLES *of the preceding processes.*

*The process.* 1. THE *water which rises first in the distillation of the recent, pure, and undigested parts of animals, whether they be solid or fluid, being again distilled with a gentle heat, in a very clean vessel, will come over pure and insipid, without affording any thing of an inflammable, oily, or saline nature.* (2.) *If the volatile, alkaline, oily spirit, which comes over second, be in like manner distilled with a very mild heat, in a tall glass with a slender neck, it affords a white, pure, dry, volatile, alkaline salt, and leaves a quantity of aqueous phlegm behind, with some oil floating on its surface; which is the thing that before turned the salt of a red or yellow colour. But if the spirit to be rectified is not of an oily nature, as spirit of sal-ammoniac, for instance, it will by this means be separated only into a pure, volatile, alkaline salt, and a clear water, which remains at the bottom of the retort.* (3.) *The oil which ascends third in the distillation being well shook and mixed with warm water, imparts a copious, alkaline salt thereto; and at the same time loses considerably of its own acrimony: and if after the oil is thus cleansed, it be committed to distillation in a glass retort, with a very moderate heat, a much more subtile oil will come over, and leave a quantity of terrestrial matter behind it; and thus, by numerous repetitions of the operation, it would, like a vegetable oil, be at length almost totally converted into earth.* (4.) *The gross, ponderous, animal oil, that comes last over in distillation, being once or twice rectified in the man-*

* The reader will observe, that all these processes are supposed to be performed upon the parts of sound animals, which enjoy'd a perfect state of health; and must expect to find a considerable difference in the phænomena, and effects of the productions, when the like experiments are made upon the corresponding parts of morbid animals. It were, therefore, greatly to be wished, that some able chemist would oblige mankind with an exact analysis of the animal solids and fluids, as altered by the various diseases whereto we are subject: which being compared with the set here offered the world, might lead us into a discovery of the cures of such diseases, in a more certain and effectual manner than those who are not chemical physicians can conceive.

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*ner just now mentioned, also deposites an earthy matter in the retort, and becomes more pure and light; approaching in its colour, scent, taste, and effects to the nature of the former. (5.) The fixed earth can only be separated from the remaining black and unctuous* caput mortuum, *by calcination in an open fire, which will gradually consume and drive away the gross oil; and by frequent ablutions in fair water to dissolve and purge it of its sea-salt; by which means it will at length become pure, white, and perfectly insipid.*

2. This process shews us, (1.) That water is the finest and most volatile part of all the animal fluids and solids, whilst they remain in a healthy, natural, and unputrefied state; and not capable of being changed by mixing with the other principles, or of receiving any thing from them, unless it be a fine sulphureous, and somewhat fetid odour, which seems indeed to be strongly and intimately impressed upon it; and in which subtile sulphur its peculiar nature, or distinguishing property, seems to consist. (2.) That the distilled spirits of animal substances are nothing but a solution of the volatile, animal salt, in water, joined with a small proportion of the lighter oil; which, however, being less volatile than the salt, this is raised before it in gentle distillation: whence the oil comes to be left floating on the top of the water, wherewith it will not readily mix; the water now, upon a second distillation, becoming less volatile than the salt or oil, tho in the first it always rises before them. This solution, or mixture of three of the principles, is called by the name of spirit; not that it is simple and uncompounded, as the principles of all things are supposed to be; but because it is volatile, and, like inflammable spirit, runs in veins or rivulets down the sides of the glasses in distillation. (3.) That the violent acrimony of animal oils consists in their salts, and are therefore made more mild and gentle by shaking them with warm water, which readily imbibes and dissolves these salts; leaving the oil more pure, and almost wholly convertible into fixed earth. Thus, having once well depurated a pound of the volatile oil of human blood, I did, by repeated distillation, turn the bulk of it into a terrestrial substance, in the same manner as Mr. *Boyle* had before converted vegetable oils, and particularly the oil of aniseeds, into a like matter; as himself expresly relates, in his discourse of the *Transmutability of chemical principles.* And therefore, when *Helmont* tells us, as he does in his *Aurora,* that in order to prepare the universal medicine, we must distil over the oil of human blood, so often as it *leaves any fæces behind it,* he either commands what he never tried himself, or else designedly imposes upon his reader, and means no more than that he shall obtain such a medicine at *Latter-Lammas*; for tho that oil be distilled ever so many times over, it will still leave a fæculent matter behind it. (4.) That the gross, animal oil has its excess of weight above the former, from the terrestrial matter wherewith it is united; whence it will sink to the bottom of the other liquid principles, before its rectification; which frees it from its earthy part, whereby it was made to appear like fluid bitumen, and renders

*The doctrine established by it.*

renders it in all respects like to the pure oil that came over befo re it. Whence we may venture to assert, contrary to the common opinion of chemists, that tho there appears to be two different kinds of oil, contain'd in animal substances, yet in reality they are but one, and differ only according to the quantity of earth that is mixed and united with them; of which however they may be in great measure deprived by repeated distillation, performed either alone, or with the addition of clean sand, or other convenient matter. And indeed, to speak strictly, there is but one single oil in all nature. (5.) That the earth afforded by animal substances, is the same with that afforded by vegetables; no difference, upon examination being to be found between them, unless perhaps that the earth of animals is the more attenuated. But as this earth has no particular medicinal virtue, any more than the water which first comes over, whatever be the subject it is procured from, 'tis manifest that all the virtues, or specific powers of bodies, as well vegetable as animal, reside in their oil, or salt; for their spirit, as we saw before, is no more than a composition of these two with water.

*The purification and doctrine of volatile salts.*

3. There are three different methods of depurating volatile salts; the first by distillation, in tall narrow neck'd glasses, with a very gentle heat, as before mention'd; by which means the salt will become more white, volatile, and less fetid; always leaving a quantity of oil behind; so that at length it seems to be wholly resolv'd into pure oil, and a saline matter: but this is not an acurate method of depurating and cleansing salts of their oil, which by remaining in them, tho but in a small proportion, will in a short time turn them yellow. Another way is therefore commonly used to effect this depuration to better advantage; and this consists in well mixing six times their own quantity of dry, pulverized chalk along with them; and afterwards subliming the mixture in tall vessels, but with a gentle heat; whereby the salts will, at one operation, be rendered exceeding white and strong; for the oil is by this means drank into the chalk, and kept from rising by the heat which carries up the volatile salt. And this method is kept as a very great secret by those who make a living of depurating the volatile salt of hartshorn, as they call it. Yet neither does this perfectly answer the intention; for the salt thus depurated, will, by being kept for some months, at length change yellow, on account of a small proportion of subtle oil brought over with it in distillation. A third and more effectual way has therefore been invented and publish'd by those excellent chemists, *Cox* and *Slare*, in the *Philosophical Transactions* of the *Royal Society* at *London*; which indeed is the best that has been hitherto discovered. Their method is upon a quantity of volatile salt, sublimed from chalk, to pour as much spirit of sea-salt as will serve to saturate it, or till the effervescence ceases; by which means there will be obtain'd a kind of sal-ammoniac; and if any oil remain'd in the salt, it will now be separated by filtring the mixture to dryness: then they add to the dry'd salt an equal quantity of salt of tartar, or pot-ashes, and afterwards sublime it in a retort; by which means they obtain a perfectly white, dry,

dry, ſimple, volatile, alkaline ſalt, entirely deprived of its oil, without conſiderably changing its nature; and therefore capable of being long kept without changing its colour. And when animal ſalts are purified in this manner, there is no difference at all obſervable between that of one ſubſtance and another, or between thoſe afforded by the different parts of the ſame, or different animals, either in colour, taſte, ſcent, or effects. Thus the volatile ſalts of urine, blood, bones, horns, hair, *&c.* appear to be perfectly the ſame, and no way diſtinguiſhable from each other, any more than the fix'd ſalts of vegetables, when well purged of their oil. Whence we may upon juſt grounds conclude, that there is in nature no more than one certain, determined, pure and ſimple, volatile, alkaline ſalt *; and that all the difference obſervable in different parcels thereof, is entirely owing to the different proportion of oil wherewith they are uſually ſo intimately mix'd and united, that it is exceeding difficult to ſeparate them; or when their whiteneſs is once loſt to recover it, and make it permanent, by repeated diſtillation, or the particular methods of depuration before delivered. Juſt as we ſee in the bones of a skeleton, which tho made perfectly white at firſt, will grow yellow with time; the oil, whereof they were not entirely deprived, exuding thro', and changing their colour. It is therefore certain, that the water, earth, and volatile alkali are perfectly alike in all kinds of animal ſubſtances; whoſe difference conſequently muſt be owing to nothing but their oil; or, to ſpeak more acurately, to ſomething that, in a very ſmall quantity, reſides therein, which may properly enough be called the preſiding ſpirit, and may be waſhed from it with water, as we formerly obſerved of the diſtinguiſhing ſpirit of vegetables. The ſaying therefore of the antient adepts, that the thing which ſets the difference between one body and another, is the *ſmall ſpark* predominant therein, proceeded from a knowledge of nature; and holds equally in animal as well as vegetable ſubſtances.

4. The ſalt, purified in the manner above delivered, is of an alkaline nature; or ſuch as will make an effervescence with all the known acids, and imbibe almoſt twice its own quantity thereof, whereby it is convertible into a neutral or ſemi-volatile ſalt, like ſal-ammoniac: and thus, if when taken into the body, it meets with no acid ſalts therein, it retains its own alkaline nature, and operates accordingly; but if it happens to unite it ſelf with any acid, it preſently becomes a kind of ſal-ammoniac, and therefore reſiſts putrefaction, and operates by ſweat and urine; being alſo cauſtic and wonderfully volatile. The ſmalleſt degree of heat will cauſe it preſently to exhale; as may be tried by laying it upon a warm metalline plate; and even riſes ſooner alcohol than in gentle diſtillation. For which reaſon it acts leſs forcibly upon the ſolids of the body, than fixt

* Conſiderable profit has been made by putting off the volatile ſalts of the cheapeſt animal ſubſtances, for thoſe of the dearer; as particularly for ſalt of hartſhorn, ſalt of vipers, &c. And it would be well if all the frauds of the trading chemiſts were as innocent as this.

ſalts, whoſe property it is to penetrate deep, and ſtick faſt in the parts they ſtimulate; ſince upon being receiv'd into the ſtomach, and inteſtines, it muſt immediately by the heat thereof be continually reflected, and beat away from the ſides toward the cavity: ſo that it is not at all probable, that it ſhould ever, like fix'd alkali, paſs the lacteals; but only act upon the *primæ viæ*, by the effluvia into which it is rais'd with a moderate warmth. It is however a powerful, ſtimulating, aperient, diuretic, ſudorific, and reſolving medicine; capable alſo of promoting inſenſible perſpiration, and of entring into the lungs, noſtrils, and cavities of the head, and mouth, in the form of inviſible effluvia, and of there ſtimulating the membranes, and altering the ſtate of the perſon, either for the better or worſe. Its cauſtic virtue is ſo great, that being externally applied to the fleſh, it eats or burns it like fire; but in order to make it have this effect, it muſt, as we have formerly ſaid, be covered with oiled bladder, or the like, to determine its force downwards, and hinder it from flying away by the heat of the body. But if managed in this manner, it will have a ſtrong and ſudden effect, ſo as in a little time to make an iſſue, or take off the hardeſt warts, or excreſcencies in the eyes, as I have frequently experienced; and perhaps too the ſame might likewiſe be of ſervice in ſchirrous and cancerous tumours. The uſe of this ſalt, by way of odour, is alſo excellent when any viſcous matter or mucus oppreſſes the membranes of the noſtrils, or is lodged about the *oſſa frontis*, *os ſphenoides*, &c. but if the membranes ſhould already be too bare, its cauſtic quality might here render it very prejudicial, no leſs than if it were taken at the mouth: and indeed 'tis eaſy for the ſcent thereof, too frequently or too copiouſly received at the noſe, to corrugate, inflame, or corrode the tender ſubſtance of the lungs, and cauſe a gangrene of the part, a peripneumonia, ſuffocation, or a phthiſis. It is therefore a pernicious cuſtom of the ladies, and eſpecially of thoſe who have weak and tender lungs, to be perpetually ſmelling at their pocket-bottles, filled with this pungent, volatile, alkaline and cauſtic ſalt. In its other virtues and reſpects, this volatile ſalt perfectly reſembles the fix'd kind, obtained from vegetables by calcination. And indeed the only difference between them is, that the one is volatile, and the other fixed in the fire; this, when rendered volatile, ſeeming to conſtitute the very ſame ſpecies of ſalt with the other. Whence we may conclude, that fixed and volatile ſalts are but one and the ſame thing at the bottom: the fixed ſalt of vegetables being thus volatilized by the power of circulation, or other forces reſiding in animal bodies, after the manner of putrefaction; whereby vegetables themſelves are made directly to afford no fix'd, but only a volatile ſalt.

*The nature of animal oils.* 5. Animal oils, before their rectification, are of an exceeding adheſive or glutinous and acrimonious nature, on account of the ſaline and terreſtrial parts mixt along with them, and the fire that is impreſſed thereon. But if by rectification, or repeated ablutions in warm water, they are once freed from their acrimony, or ſalt, they loſe their cauſtic quality: and if the earth be entirely taken away, they remain no longer adheſive; but become

come more pure, ſubtile and penetrating; whence, tho being applied to the skin, they would before this depuration inflame, corrode, or even cauſe a gangrene of the part; they now become of a mild and innocent nature. And this will ſhew us that we ought not to be too liberal in the internal uſe of unrectify'd oils, becauſe of the ſalt wherewith they abound; which might eaſily render them corroſive to the ſtomach, purſe up the veſſels thereof, or burn its coats, as it were, to a cruſt.

## PROCESS CX.

### *Shewing that* animal alkaline ſpirits *will coagulate with alcohol, and give the* offa alba *of* Helmont.

1. *TO a proper quantity of a volatile, animal, alkaline ſpirit, that is well purged of its oil, ſaturated with ſalt, and contained in a glaſs veſſel firſt made exceeding cold and dry, add an equal proportion of pure alcohol, in a place where the air likewiſe is very cold; then where the two tranſparent liquors touch each other, there will immediately be formed a plate of ſolid opake matter: but if the containing vial be ſhook, the whole mixture will inſtantly unite and coagulate together into a white ſolid maſs; which may again be liquified by the leaſt degree of heat; but in its ſtate of coagulation cannot be made to fall out at the mouth of the glaſs.* *The proceſs.*

2. This experiment will not ſucceed unleſs the alcohol be perfectly clear'd of all aqueous particles, and the volatile alkali be thorowly depurated, and rich in ſalt. Upon which account it has by ſome been treated as a mere fiction of *Helmont*, who pretends to the invention, tho without diſpute *Raymond Lully* deſcribed it long before his time: but the thing ſucceeded not in their hands for want of due attention to the requiſites. The alkaline ſpirit contains ſalt enough for this purpoſe, when ſome quantity will lie undiſſolved at the bottom thereof; and if the ſame be well freed from its oil, and the alcohol be alſo pure, ſucceſs will attend the experiment. *The cautions required to make it ſucceed.*

3. The production or coagulum of this proceſs is a wonderfully volatile and perfect ſoap; the alcohol being a moſt ſubtile oil, and the other ſpirit containing an alkaline ſalt, ſo highly attenuated as to become exceeding volatile. The virtues and uſes of the mixture may therefore be underſtood from what we formerly ſaid of ſoap; only in this caſe the ingredients are much more volatile than in the other ſoaps. By repeated diſtillation theſe two ſpirits may be intimately united; upon which their ſalt will ſhoot into cryſtals, conſiſting of thin flat plates; yet remain inſtantly ſeparable again by the admixture of acids; tho the whole mixture is at the ſame time of an alkaline nature. *Nature of the production.*

*Physical and chemical uses of the process.* 4. This experiment shews us that the most fluid and volatile bodies in the known world may be instantly turn'd to solids, by nothing more than bare mixture; which a person could scarce believe without the immediate testimony of his senses. Here likewise we have an instance of the great attractive power there is between volatile salt and volatile oil; as we formerly saw it betwixt alcohol and fix'd alkali in the preparation of *Helmont*'s tincture of salt of tartar. But notwithstanding the strict union of the salt and alcohol in this coagulum, it has no pretence for being *Helmont*'s *Alkahest*, as *Starkey* imagined; because it may so easily be destroyed by acids, or by water.

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## Chemical History *of VOLATILE OILY SALTS, made by means of* sal-ammoniac.

### PROCESS CXI.

#### *Exhibiting the production of simple* SAL VOLATILE OLEOSUM.

*The process.* 1. *To twenty-four parts of pure alcohol, add one part of any distilled aromatic oil, as of rosemary, for instance; mix them together into a liquid quintessence; and afterwards shake with them twenty five parts of highly rectified spirit of sal-ammoniac, and immediately there will be made a coagulum, as in the preceding process; which being once or twice gently distilled over in a retort, till the dry volatile salt sticking to the sides of the vessels begins to dissolve, gives a simple* sal volatile oleosum, *or a volatile, saline and oily liquor.*

*How varied.* 2. This *sal volatile* may be varied at pleasure, by the use of particular essential oils; the same proportion being always observed, and the two other ingredients remaining the same. Thus there may be made a *sal volatile* of cinnamon, citron-peel, &c. the liquor taking its denomination and particular virtues from the essential oils of those vegetables. And as the alcohol, the distilled oil, and the spirit of sal-ammoniac are evidently united in this liquor, it has by some been called the lesser animal elixir.

PRO-

## PROCESS CXII.

### *Shewing the manner of preparing compound* SAL VOLATILE OLEOSUM.

1. *MIX together equal parts of any compound ſpirit of aromatic vegetables, and the rectified ſpirit of ſal-ammoniac, and diſtil them over twice or thrice with a gentle heat in a glaſs retort, carefully luted to its receiver; and what comes over is a compound* ſal volatile oleoſum; *the diſtillation being continued till the ſalt adhering to the glaſs juſt begins to diſſolve.* *The proceſs.*

2. The deſign of the proceſs might likewiſe be effected with a mixture of different eſſential oils, as well as compound ſpirits; ſo as to yield a *ſal volatile* of any medicinal virtues that ſhall be required. But if a dry aromatic ſalt, without any volatile ſpirit, be the thing in view; no alcohol need be added, and only a proper proportion of eſſential oil poured to the dry ſalt before obtained: then the operation being performed in the gentle manner above mentioned, a dry, white, aromatic ſaponaceous ſalt will ſublime and adhere to the ſides of the glaſſes. And thus all thoſe commonly called by the name of *Engliſh* ſalts are conſtantly prepared *. *Varied.*

## PROCESS CXIII.

### *Exhibiting the method of procuring ſpecific* SAL VOLATILE OLEOSUM; *by an example in that of* LAVENDER.

1. *TO four ounces of recent lavender flowers, add twenty-four ounces of rectified ſpirit of wine, two ounces of ſal-ammoniac, and an ounce of ſalt of tartar. Put them together into a glaſs retort, and carefully lute it to a large receiver, and diſtil with ſuch a degree of fire as will juſt ſerve to make the matter boil; upon which there will ariſe a volatile ſalt, in a dry form, poſſeſſed of the ſpecific virtue of the plant; and afterwards a ſpirit of the ſame nature therewith, which is to be drawn off till the phlegm begins to riſe, ſo as to diſſolve the dry ſalt; and then the operation is to ceaſe. But if what thus comes over be poured back upon a parcel of freſh flowers, the medicine will thereby be made the more efficacious.* *The proceſs.*

2. If inſtead of lavender any other aromatic vegetable, of known ſpecific or medicinal virtues be here made uſe of, its *ſal volatile oleoſum* may in like manner be obtained, under the particular name thereof. And thus may be made the *ſal volatile* of rue, which is a good antihyſteric; of ſavin, *&c.* which powerfully aſſiſts in expelling the fœtus, or forward- *How to be varied for the purpoſes of medicine.*

* Theſe are the volatile ſalts which the ladies generally carry in their pocket-bottles; and uſually by foreigners termed *Engliſh* ſalts.

ing delivery; or of opium, which has the power of ſtupifying almoſt inſtantaneouſly. And ſo the *ſal-volatile* of other vegetable productions may be made to participate of their medicinal virtues.

## PROCESS CXIV.

### *Exhibiting the extemporaneous manner of producing* SAL VOLATILE OLEOSUM.

*The proceſs.* 1. R*Educe equal quantities of pure ſalt of tartar, and ſal-ammoniac to powder; put them into a clean glaſs veſſel, and pour upon them twelve times their own weight of well rectified ſpirit of wine, and half as much of any eſſential aromatic oil, or a mixture of ſeveral kinds thereof, as of either of the ſalts; ſhake them all well together, and the fixed alkali will immediately volatilize the alkaline part of the ſal-ammoniac; whilſt it drinks in the aqueous moiſture of the ſpirit of wine: whence, of courſe, the purer ſpirit, the eſſential oil, and the volatile ſalt will directly be united into a* ſal volatile oleoſum.

*Hiſtory of the production.* 2. The firſt who wrote of theſe volatile ſalts was *Baſil Valentine*; but he delivered himſelf obſcurely upon the ſubject. *Helmont* afterwards treats of them in his book *of the Stone*; where he is large upon the volatile ſalt of urine. But *Sylvius* was the firſt phyſician that introduced them into medicine; and he recommended them ſo earneſtly, as an univerſal remedy, that it gave occaſion to ſell them at a very exorbitant price. After *Sylvius*, *Tachenius* prepared a volatile ſalt of vipers, and valued it highly as an admirable remedy againſt the ſtone and gravel: and in a ſhort time after, theſe volatile ſalts were every where in general uſe and eſteem.

*Its medicinal uſes.* 3. All theſe kinds of *ſal volatile oleoſum* are moſt properly employed in ſuch diſtempers where any acid humor is to be corrected, any thing viſcid or tenacious to be attenuated, or any thing coagulated to be reſolved; where heat is to be increaſed, the ſtrength recruited, or ſluggiſh motions to be quickened. Which gives to ſee how noble a medicine they are in abundance of chronical diſeaſes, proceeding from a viſcid, cold or acid cauſe; as particularly in the acid ſcurvy, and the acid gout. But, on the contrary, in acute caſes, when an alkaline corruption reſides in the body, and the blood, or oils thereof are already broke too ſmall, it is very unſafe to uſe them, as being here of a very poiſonous and pernicious nature. They muſt therefore be carefully avoided in caſe of a *phthiſis*, where there is a diſpoſition to bloody urine, or the like; and, in general, wherever the ſalts of the body are of an alkaline nature, or tending to putrefaction. When their uſe is proper, they are taken to beſt advantage, in a conſiderable doſe, ſeveral times in the day, along with a glaſs of generous wine. To preſcribe them after the vulgar manner, in the quantity of a few drops, is doing little to the purpoſe: they muſt be given by a dram at a time; ſo that a whole ounce, may, in caſes of neceſſity, be taken

in a day, if we would expect to reap the benefit thereof. And in this manner I have prescribed them with good success. But if the internal parts of the body are to be altered or impregnated with their virtue, they ought to be taken upon an empty stomach, drinking a draught of some warm liquor upon them, whilst the patient remains in bed, or using gentle exercise after he rises, so as to cause a light appearance of sweat upon his body, or at least a disposition thereto. They are likewise frequently used externally, and may be readily made into a dry form for smelling-bottles, by a gentle sublimation in tall glasses; and thus they powerfully stimulate the nerves, and recover from epileptic and hysteric fits. But when applied too frequently to the nose, they may prejudice the lungs, or *membrana Schneideriana*. They also make an excellent potential cautery; being applied to any part, and covered with a piece of bladder to prevent their exhalation. And lastly, they admirably serve to discuss and resolve hard tumors; being diluted with a large proportion of water, and used in the way of fomentation; provided there are no signs of putrefaction in the body. Hence it is evident, that the use of these salts is indeed very extensive, tho not so universal as some have thought it, or as their extravagant commendations would persuade one.

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# CHEMICAL HISTORY *of the* BLOOD.

*Introduction to the history of the blood.*

WE have now seen, in a competent number of select examples, the resolution of all the animal solids and fluids, of what principles they are composed, and what medicines they afford by composition. Nothing more remains to be done in this second part, which treats of the animal kingdom, than to shew what phænomena or changes are producible in the blood, by means whereof all the parts of animals are repaired, upon mixing it with the productions of our preceding processes, or the more active principles of bodies; as particularly with alcohol, oil, water, and different kinds of salt. This knowledge is so requisite to a physician, that it is impossible he should ever understand the effects, or explain the operation of medicines without it. To make these experiments with the greatest advantage, it seems most proper to chuse the *serum* rather than the *crassamentum* of the blood, or the mixture of them both as they come from the vein; for the effects will be nearly the same in both, but the *serum* is much the more commodious for experiments.

PRO-

## PROCESS CXV.

*Exhibiting the phænomena of the* BLOOD *upon mixing with various forms of salts, and oils, by particular experiments made on the* Serum.

*The experiments.*

1. *EXPOSE any quantity of healthy blood, newly extracted from the vein, for the space of twenty or thirty hours to the open air, in a clean vessel, and it will separate, as it cools, into two different parts, a light yellowish liquor, or serum, and a red, congealed mass, or crassamentum, that when separated from the sides of the vessel, appears like an island in the ocean, and sinks to the bottom of the serum* *; *which, being decanted clear, and mixed with a proper proportion of warm water, to reduce it to the same degree of heat it had in the body, will, by being severally mixed with the following materials, afford the following phænomena.*

2. *Upon putting together equal quantities of the serum of healthy human blood, prepared in the manner above-mentioned, and the oil of tartar* per deliquium, *the serum appears rather coagulated than made thinner, and its colour immediately changes to whitish; an alkaline vapour arising from the mixture: which shews us the effect of fixed salts upon the blood.*

3. *If, in like manner, the same proportion of the pure and strong spirit of sal-ammoniac be mixed with the serum, it will be diluted or thinned indeed, but scarce discover any alteration in its scent or colour. Thus also, the like proportion of the strongest and most fiery spirit of the same salt, distilled with quick-lime, dilutes the serum, tho it neither alters the colour, nor makes any effervescence therewith; but gives it, however, an acrimonious taste. And the same holds good of the rectified spirit of digested urine: whence we are given to see the different effects of fixed and volatile alkalies upon the blood.*

4. *Add to the first mixture,* viz. *that of oil of tartar with the serum, any quantity of spirit of vitriol, and there will arise a strong effervescence and expansion; but it will scarce return to its former fluidity. The same spirit being poured to the second mixture, that with the pure spirit of sal ammoniac, affords the like phænomena. But if spirit of vitriol be added to the third, that with the fiery spirit of sal-ammoniac, it makes no manner of effervescence; but*

* If there be numerous air-bubbles in the fibrous part of the blood, as sometimes is the case, it will not readily, or perhaps not at all, sink below the serum; the difference of their specific gravity being not very considerable: which has given occasion to some mistakes about this matter. To say the truth, it seems to have been little considered that the blood of different persons may differ as to its gravity; whilst we look upon blood, in the general, as a certain immutable fluid, that is constantly of the same weight; tho the specific gravity of no fluid is absolutely the same for any two successive moments, and differs with the seasons of the year, heat and cold, the time of the day, &c. and so, in particular, does the blood with the several stages of life, changes of the body, diseases, and numerous other circumstances: whence it should seem that general conclusions ought not to be hastily drawn about this matter.

*suffers*

*suffers it to remain, as it were, in its former state. And lastly, upon adding the same spirit of vitriol to the mixture of spirit of urine and serum, the effect will be the same as in the mixture of the serum, the pure spirit of sal-ammoniac, and spirit of vitriol; excepting that the inspissation is not so strong.*

5. *But if the spirit of vitriol be added to pure and unmixed serum, it will be instantly coagulated, and turned white thereby, as if it had been boiled at the fire: and then the addition of oil of tartar makes a violent effervescence. The spirit of sea-salt makes a perfect coagulation of the serum; but with very different phænomena from those occasioned by the acid of vitriol: and the addition of oil of tartar causes a considerable effervescence; at the cessation whereof the sea-salt is regenerated from its spirit. The spirit of nitre instantly makes a strong coagulum of the serum, in the same manner as oil of vitriol, and yields a copious effervescence upon the affusion of oil of tartar; after the disappearance whereof, the nitre is found to be regenerated. On the contrary, strong spirit of vinegar greatly dilutes the serum; and the affusion of oil of tartar here cannot make any effervescence, but coagulates the mixture.*

6. *A solution of sea-salt in water causes no change of colour in the serum of the blood, but dissolves its texture a little; tho without causing any effervescence. And the like solutions of sal-gem, borax, nitre, and sal-ammoniac, do much the same; except that borax causes no alteration in the texture of the serum. But* Glauber's *salt, or that which in* England *goes by the name of* Epsom-*salt, instantly makes a strong coagulum thereof, and turns it white, as if oil of vitriol had been mixed therewith.*

7. *The affusion of* sal volatile oleosum *coagulates the serum on account of the alcohol it contains; after which, the addition of oil of vitriol makes only a moderate effervescence therewith. And, indeed, all saponaceous substances, which are a mixture of oil and alkaline salt, thin the blood, without causing any effervescence; tho of oil it self be added thereto, it prevents its mixing with water: but the tincture of salt of tartar, prepared with the purest alcohol, and the strongest fixed alkali, being mixed with the serum, preserves it in a neutral state; for the alcohol tends to coagulate, and the alkali on the contrary to dissolve it, whence it becomes neither thicker nor thinner thereby.*

*The doctrine they afford, as to the coagulation and liquefaction of the blood by medicines.*

8. From the preceding particulars, we may draw this general conclusion, that the thing which strongly coagulates the blood in the human body is of an acid, and not of an alkaline nature; since all acids, except vinegar, are found to coagulate it, and all alkalies to dissolve it out of the body. Whence we may learn, that it was rightly judged of *Hippocrates*, tho he has been blamed for it, to prescribe the use of vinegar in ardent fevers, and all distempers proceeding from a lentor in the blood, or where it was requisite to dissolve or dilute it. And indeed vinegar appears to contain one of the most innocent acid salts in nature. But *M. Homberg* tells us in the *Memoirs* of the Royal Academy of *Paris*, that the spirit thereof concentrated, or reduced to its greatest strength, will, instead of dissolving, really coagulate the blood. And this I will not deny to be true; for I am sensible, to speak strictly, that acid salts do not coagulate the blood merely on account of their acidity, but

but by their austerity, or constringing power, which presses or determines the liquor they are mixed with to a solid form; and which the vinegar may acquire by the operation. We see, however, that the direct method to dissolve or thin the blood in the body, is by the use of alkalies; which for that purpose need not be of the strongest or most fixed kind, which might sometimes prejudice the finer canals by their corrosive property; but such medicines as the tartarized, or regenerated tartar, the solution of the *sal Tachenii*, or the like, may be safely and advantageously used in case of coagulated juices: for these, at the same time that they dissolve, improve the colour of the blood, and render it more florid and healthy. On the other hand, it must be observed, that the exhibition of acids may frequently prove prejudicial, and especially in inflammatory fevers, by increasing the lentor or viscidity of the blood and juices, which by causing obstructions in the smaller vessels, give rise thereto; tho some are so ignorant as to imagine that acid salts have the power of fusing rather than coagulating the humors, and causing obstructions. But we may be certain, that hot water, aqueous solutions of vitriol, allum, salt of steel, sugar of lead, alcohol, and all acid spirits, vinegar alone excepted, thicken and coagulate the blood; and on the other hand, that cold or luke-warm water, aqueous solutions of sea-salt, sal-gem, nitre, borax, sal-ammoniac, regenerated tartar, and all alkaline spirits and soaps, under which vinegar may well enough be included, as containing a salt and oil strictly united, liquify and dissolve the same.

SECT.

# SECT. III.

## *Exhibiting a Course of* PROCESSES *upon* FOSSILS; *the most irresoluble and inorganical Class of Bodies.*

## CHEMICAL HISTORY *of* FOSSIL SALTS.

METALS, tho the most simple of mineral bodies, are of a less tractable nature than fossil salts, and cannot be chemically treated without their assistance; for which reason we are obliged to open this Section of processes upon fossils with those, as preparatory to our examination of metalline bodies; and in particular with that salt which participates least of a fossil nature, or appears a kind of neuter in the three kingdoms; *viz. nitre*, or *salt-petre*. *Introduction to the history of fossil salts.*

## CHEMICAL HISTORY *of* NITRE.

THERE are generally reckoned three different origins of nitre: for first, it is found in lime-stones, or the mortar of old buildings; secondly, it is dug up in a fat soil, as in *Sumatra*, or particular parts of the *East-Indies*; and lastly, it is met with in those places where large quantities of the excrement and urine of such animals as use no sea- *Origin of nitre.*

ſea-ſalt, have long been laid. It may likewiſe be obtained by mixing fixed alkali with a ſmall proportion of animal dung, and keeping them for a long time together. And we ſometimes obſerve it adhering to, or, as it were, growing out of the walls of wine-vaults, or other moiſt and warm places.

## PROCESS CXVI.

### *Exhibiting the artificial method of procuring* NITRE.

*The proceſs.* 1. R*Educe to powder a proper quantity of the friable lime of old walls, or the dry excrement of ſuch animals as never uſe any ſea-ſalt, after having long lain in large heaps expoſed to the air; boil this powder in water, and it will communicate its ſaline parts thereto: then filtre and exhale the lixivium to a pellicle, and ſet it in the cold, where it will ſhoot or concrete into a ſaline lump, or nitre; which is cool upon the tongue, and almoſt taſteleſs, unleſs for a very faint bitterneſs it leaves behind.*

*How performable to advantage.* 2. This ſalt might be obtained in greater plenty, if to the lime or other matter which affords it, were added a proper quantity of fixed alkali, or wood-aſhes, ſometime before it comes to be made uſe of. But if, inſtead of that, ſea-ſalt, or ſal-gem be added thereto, it will not be nitre that is obtained by the operation, but ſal-ammoniac. And after this manner they make ſalt-petre in different parts of *Europe*, from a fat kind of earth, dug up in particular places, and capable of affording it to profit. But all that is brought to us from the *Eaſt*, is purely foſſil, or what they dig in ſubſtance from the earth; and this generally appears of a brown colour. But whether the nitre of our times be the ſame with that of the antients, may be juſtly queſtioned. They generally called their nitre by the name of *Cyrenaic* or *Egyptian*, in which places it was found common, as there concreting from the urine of animals. And by comparing the account which *Dioſcorides* gives of it, with that of *Hippocrates*, it is plain that their nitre was no other than our ſal-ammoniac; the virtues which they deliver of the former, perfectly agreeing with thoſe of the other.

*Characters of the production.* 3. This ſalt of it ſelf is neither acid nor alkali, tho it may eaſily be converted into either. It fuſes at the fire with more eaſe than any other ſalt, and as readily diſſolves in water: when pure it is not at all inflammable, nor yields any ſparks in the fire. But if any ſalt or oil remains fixed to it, that indeed may flame, as being the only thing in nature that is inflammable. And ſo if ſulphur be thrown upon it whilſt it is in fuſion, it will then be more ſtrongly agitated, and thereby rendered ſtill the more inflammable: ſo that tho of it ſelf it be, contrary to the common opinion, incapable of taking fire; yet it may and does contribute to increaſe the flame of the ſulphur, by adding to the motion of its parts. This ſalt has likewiſe a very refrigerating faculty;

faculty; so that it not only cools water, but allays the heat of the blood better than any other salt whatever; and indeed is the only one that will produce a considerable degree of cold therewith: on which account I highly esteem it in inflammatory distempers, where sea-salt would increase the heat instead of allaying it.

## PROCESS CXVII.

### *Exhibiting the manner of purifying native or common* NITRE, *by crystallization.*

1. B*OIL any portion of native or lump-nitre, in six times its quantity of fair water; and whilst the lixivium remains hot, run it thro' the filtre into a wide vessel, with a flat bottom, and exhale it over the fire till a pellicle appears on the surface: then place several small sticks of wood, from side to side, in the vessel, below the liquor, and set it in a cool place to shoot; upon which, saline transparent glebes or crystals, in the figure of hexagonal prisms, will presently be found adhering to them; and these glebes are pure, crystalline nitre, fit for medicinal uses, and the other purposes of human life.* *The process.*

2. No salt runs into crystals so soon as nitre; whence, if it be not very hot whilst it passes the strainer, it will concrete and grow hard by the way. It ought to be set to shoot in a wide vessel; for this will make the crystals the larger and fairer. But if there be any suspicion that another salt is mixed along with the nitre, let the operation be repeated, and now boil the lixivium with a small proportion of fixed alkali; skim it well, and pass it again thro' the filtre; lay sticks in the containing vessel, as before, and suffer it to crystallize afresh; and by this means it will be made perfectly pure. Which is the method used by the workmen at the salt-petre mines, to free their nitre from any unctuous matter that may happen to adhere thereto, and prevent its shooting: for this addition of fixed salt draws to it as well the oil as the superfluous acid that is mixed along with it, yet without cleaving to the nitre it self; which is wonderfully prevented by the separating principle of crystallization. *Directions relating to it.*

3. This is the proper and highly useful method of separating and purifying all manner of salts by means of crystallization; which is the only genuine operation that gives to every salt its purity, form, and peculiar nature, or marks which distinguish them from all others, wherewith they might be accidentally united; for tho any number of different salts should be promiscuously blended in the same common lixivium, yet if this were set in the cool to shoot, the salts would separate from one another, put on their proper form, and appear in peculiar crystals, according to their respective natures. Crystallization, therefore, is an incomparable method of separating one salt from another. *Its chemical use.*

*Farther improved.* 4. If the nitre purified in this manner be put into a crucible, and once fused at the fire, where it will run with great facility, it thereby becomes the most perfect nitre that can well be obtained; being thus every way freed from its oil, which might render it unfit for several uses, as particularly for making good *Aqua fortis*, or good gun-powder. And this is the nitre that I constantly make use of, both in chemistry and medicine, without the addition of any other mattters, which, instead of improving, really alter its nature, or render it impure. And whoever makes trial of it, thus prepared, will find it an admirable refrigerating and resolving medicine, most highly serviceable in ardent fevers, and other acute diseases. And if it be boiled in a decoction of red poppy-flowers, and the solution be filtred and crystallized in the manner already mentioned, it will be turned to a beautiful red, transparent salt, which has formerly been sold at a very high price, as an admirable and most effectual medicine: for by this means it is so neatly disguised, that it cannot well be distinguished; and is certainly endowed with very great medicinal virtues.

## PROCESS CXVIII.

*Exhibiting the method of converting purified* NITRE *into fixed alkali, with tartar.*

*The process.* 1. TAKE *equal quantities of purified nitre and clean* Rhenish *tartar, and grind them together to a fine powder, small parcels whereof being, a due intervals, put into an iron vessel made almost red-hot, there will a great deflagration be made at every injection, with a violent effervescence and ebullition; and at length, when in this manner all the powder is thrown in, it will presently be totally changed into a green and violent fixed alkaline salt.*

*What caution it requires.* 2. Regard must be had in this operation not to inject too large a quantity of the powder, at once, into the iron vessel; which might prove of dangerous consequence; for it immediately takes fire, like gun-powder.

*Its effects.* 3. Here we see that nitre, which of it self will never flash in the fire, may readily be made inflammable by the injection of tartar, a vegetable acid salt, containing a copious oil; and thereby be instantly converted into fixed alkali: which indeed is the most expeditious method hitherto known in chemistry of procuring it. And this may serve to shew us the natural affinity there is between nitre and vegetable salts, since it may so easily be changed into them.

*Uses of the production.* 4. The production of this process may be used in all cases, whether medicinal or chemical, where fixed alkali is required; being it self really a fixed alkaline salt, of a very violent nature, and as such acting even upon metals.

## PROCESS CXIX.

### *Exhibiting the manner of converting purified* NITRE *into fixed alkali, with a glowing coal.*

1. F*USE a proper quantity of pure pulverized nitre at the fire, and when it runs put a small portion of live charcoal, or other kindled vegetable fewel, into the crucible to it, and a great flash, attended with a considerable report, will presently break out; then, the former being consumed, throw a fresh coal into the crucible, and repeat the injection till the flashing and report entirely cease; upon which the remaining nitre will be turned into a blue-coloured fixed alkali, stronger than almost any other that can be procured, or as violent as salt of tartar it self.* *The process.*

2. In this process, also, the quantity of fewel injected at once should not be large, for fear of any mischievous effect, by the bursting of the crucible; the explosive force being frequently so great as to throw out the injected coal with a considerable violence. And this happens altho the nitre it self is not actually kindled; but as it thus strongly agitates the coal, it causes it to flash with great violence. *What caution it requires.*

3. Hence we learn, that a fixed alkali is producible by a small quantity of fire, or without the assistance of a thorow calcination; and that the whole body of nitre is thus convertible into alkaline salt, unless perhaps its spirit flies off in the operation, in the form of vapour, which is not prejudicial, but wholesome to the body, and said to be a preservative against the plague. *Its chemical effect.*

4. If this fixed alkali be exposed to the moisture of the air, it is thereby presently made to run, like salt of tartar *per deliquium*, into an unctuous, alkaline liquor, which *Glauber*, its inventor, took for the alkahest: but in this he was grievously mistaken; such liquor being no more than the alkali of nitre, fixed by the inflammable vegetable used in the preparation, and run into a fluid by the moisture of the air, which it strongly attracts. What led *Glauber* into this mistake, was its great power as a menstruum, whereby it dissolves various bodies; tho in reality it is scarce preferable, for that purpose, to oil of tartar made *per deliquium*; having entirely the same virtues therewith, except perhaps it is of a somewhat more penetrating nature. There is, however, a remarkable book in *French*, which I have seen, wrote entirely upon this subject, by a jesuit, under the title of *The universal medicine.* *Nature of the production.*

## PROCESS CXX.

### *Exhibiting the manner of Converting* NITRE *into* Sal Prunellæ, *with Sulphur.*

*The process.* 1. *TO a proper quantity of pure nitre, fused at the fire in a crucible, throw a small proportion of sulphur, not exceeding the twentieth part thereof; and there will instantly ensue a very smart fulmination, with so bright a flame, that it proves almost too strong for the eyes. When this phænomenon ceases, the same quantity of sulphur may, in like manner, be injected, and the operation repeated for two or three times; then the sulphur appearing to be wholly consumed, the remaining matter is to be poured out to cool, under the name of* Sal Prunellæ.

*Its use.* 2. This process shews the foundation, and possibly the origin of gun-powder; nothing being here wanting but the coal, to constitute that destructive composition: and what service the coal performs therein, may be learnt from the preceding process. The production is called *Lapis* or *Sal Prunellæ*, not that it is ever obtained from the plant self-heal; but because the *Germans* observing it to cure the inflammatory, or gangerous species of the *Angina*, which they term *de Brune*, as effectually as the *Prunella*, they affixed that appellation thereto: tho to speak the truth, the pure nitre, without addition, or without undergoing this operation, seems, in this case, to be a much better medicine, and more adapted to the cure of the quinsy.

## PROCESS CXXI.

### *Exhibiting the manner of Converting* NITRE *into* Sal Polychrestus, *with Sulphur.*

*The process.* 1. *GRIND equal quantities of purified nitre, and the finest sulphur, together, into a subtile powder, to be thrown, by small quantities at once, into a clean, ignited crucible; and upon each injection there will immediately arise a fulmination, like that of gun-powder: which being over, the operation is to be continued till the whole mixture of the nitre and sulphur is thus deflagrated. What now remains in the crucible must be fluxed, or continued in a calcining heat, for the space of half an hour; then the vessel being suffered to cool, take out the matter, and preserve it under the name of* Sal Polychrestus.

*Varied; with the virtues and uses of the production.* 2. This process might otherwise be performed by frequently injecting small portions of sulphur upon the fluxed nitre, in the manner of the preceding, till what is thus cast in amounts to an equal quantity, or till the matter fulminates no longer, but only flames like sulphur. And the

the salt obtained in either manner, may, by repeated solutions, filtrations and exhalations, be reduced to any desired degree of purity. This is a salt of a peculiar nature, being semi-saline, and semi-sulphureous, neither acid nor alkaline, but somewhat bitter, and exceedingly like that mineral or fossil salt which is dug up in such pits as lie near the veins of some mineral springs. On account of its numerous medicinal virtues, it has obtained the name of *Sal Polychrestus*; and accordingly it is called by the *French*, *Sel de pleusieurs usages*, the salt of many virtues. And indeed it is a noble medicine in all those acute diseases which are curable by aperients, and refrigerants; this salt producing its effects, without causing any inflammation or disturbance to the body. It is the most powerful resolver of all the salts hitherto known; being without equal, and very different from all others; as consisting of the fixed parts of nitre and sulphur, strictly united together. Taken in the quantity of a dram, in the morning fasting, 'tis an admirable, gentle cathartic; half a dram proves a sudorific or diuretic; and in the dose of two drams, it will generally prove a moderate emetic. In all mild intermitting fevers, it is as infallible as the *cortex*; being given in a proper dose, dissolved with some convenient liquid, two hours before the fit is expected. It likewise wonderfully disposes the body for the cure of obstinate quartans; and will sometimes even effect the cure it self. Being a neutral salt, it is likewise so innocent that it may safely, and to advantage be given in continual fevers; and I have always found it is of very great service in epidemic cases. In short, it performs as much as can well be desired of a medicine, and answers all the various intentions of the physician with the greatest ease and safety.

## PROCESS CXXII.

### *Exhibiting the Distillation of Spirit of* NITRE *with Bole.*

1. *TO one part of purified nitre reduced to fine powder, add three of the dry powder of common red bole-armeniac, and grind them together for a considerable time, the longer the better; and with this mixture fill two thirds of a low, coated retort, made with a large neck; set it in an open fire, lute on a capacious receiver, with the* lutum sapientiæ, *so that it may lie horizontal, and carefully distil with due degrees of heat; by which means there will, with a slow fire, come over, for the first two or three hours, an acid, pale, watery liquor: when this is all risen, increase the fire, and a kind of unctuous spirit will begin to ascend, and keep coming over for two or three hours more: after this is all come off, increase the fire again, till red fumes appear in the glasses; and continue the same degree of heat as long as any of them are to be seen; then give the last degree of fire, and keep it up for two or three hours, so as to make the retort red hot; upon which the fumes will seem of a dark red, and a red liquor will come over. When this ceases to run, let the fire go out, and the vessels* *The process.*

*vessels cool. The liquor that will now be found at the bottom of the receiver, is a smoaking and exceeding acid spirit of nitre; whilst only a parcel of dry bole, to appearance, remains at the bottom of the retort. But if any salt be still mixed therewith, it is not converted into fixed alkali, but may, by solution in water, filtration, and crystallization, be reduced to the form of nitre again.*

*Cautions relating to it.* 2. The production of this process should not be rashly approached; and care ought to be used in pouring it out of the receiver into the vessel designed to keep it; for if this be imprudently done, it may prejudice the lungs by its corrosive fumes. The spirit of nitre, therefore, is most properly handled, or poured from one vessel to another under a chimney, which may give passage to its effluvia. And in order to detain and keep this spirit in the glass, it must either be stopped down with a glass-stopple, or one of wax; for it would presently eat thro' cork.

*Its effects.* 3. We learn from this experiment, that the fire greatly attenuates nitre, when prevented from flowing therein by means of bole, dried clay, or the like, so as to render it volatile, and turn it into an exceeding acid and unctuous liquor, which may be called the spirit of nitre, or *Aqua fortis*; being indeed the general basis of the menstruums for metals, and the only one that dissolves the human *calculus*; tho not capable, on account of its corrosiveness, of being taken internally. But if this distillation was to be made in an earthen vessel, without addition, the nitre would pass thro' the pores thereof, and not be separated or changed into an acid; which shews us the use of the bole in this process.

*And transmuting faculty.* 4. Hence we infer that the fire has a surprizing power of converting a fixed, neutral, and almost tasteless salt, into a violent acid, volatile and corrosive liquor; at the same time giving it a strong solutive power, whereby it acts even upon metals themselves: for nitre of it self is no solvent of metals, tho its spirit dissolves them so powerfully. And it is very remarkable, that the whole body of the nitre is thus convertible into this acid, without any separation being made thereof into its principles; for, as we before observed, if the fire has not been violent or long enough continued to drive it all over, what remains mixed with the bole, is really and truly nitre; so that the spirit obtained by our process is an actual transmutation of the nitre. And in the same manner may acid spirits, otherwise called oils, be procured from the other fossil salts; as particularly vitriol, tho this requires a particular, cautious treatment, and a violent fire for the purpose.

## PROCESS CXXIII.

### *Exhibiting the preparation of* Aqua fortis, *or* Glauber'*s Spirit of* NITRE, *with oil of vitriol.*

1. *TO a proper quantity of purified nitre, well dried, pulverized, and put into a dry and ſtrong glaſs retort, carefully pour an equal proportion of pure oil of vitriol, avoiding the noxious fumes, ſo that the whole mixture may not poſſeſs more than two thirds of the retort: red fumes will inſtantly ariſe in the glaſs; then preſently lute on a large receiver, with the* lutum philoſophorum, *and diſtil with degrees of fire, in a ſand furnace; upon which the veſſels will ſoon be filled with fumes of a colour between black and red; then the fire being increaſed thro' all the degrees, and the operation continued till nothing further comes over, let the glaſſes cool, and there will be found at the bottom of the receiver a real* Aqua fortis, *or a much more corroſive, acid, and fiery ſpirit than that of the preceding proceſs; being ſo volatile as ſpontaneouſly to go off in red, copious, ſuffocating fumes.* *The proceſs.*

2. This is the ſtrongeſt and cleaneſt ſpirit of nitre that can by any means be procur'd; and the beſt for chemical uſes, or in all thoſe caſes where it is required pure and genuine: for it is, in reality, only the body of the nitre it ſelf, and not the oil of the vitriol, as might be ſuſpected; which is manifeſt from hence, that pure nitre may be again recovered from the liquor. But that which riſes firſt is weaker and leſs efficacious than the production of the preceding proceſs. The fumes of this ſtrong ſpirit are to be carefully avoided, as highly ſuffocative, in opening the containing glaſs; which likewiſe muſt be ſtopped with wax or a ſtopple of glaſs, for its parts would readily paſs thro' wood or cork. *Glauber* was the original author of this proceſs, who made a great advantage of the production, by keeping it for ſome time ſecret, and ſelling it, at his own price, to the chemiſts of different countries; among whom it was uſually called the blood of the ſalamander; on account perhaps of the colour of its fumes, and the vehement fire required to raiſe it. And in the ſame manner the acid ſpirits of allum, *&c.* are obtainable by mixing them with oil of vitriol. *Nature of the production.*

3. Hence we ſee that oil of vitriol has the power of volatilizing ſalt-petre, and of turning it from a neutral ſalt into an acid ſpirit, without leaving any fæces behind: for if any part remains unconverted into this fluid acid, it unites with the oil of vitriol, and changes into a third body *. And thus we ſee that nitre is convertible into acid, as we before ſaw it was into alkali. We may add, that it ſhould ſeem from *Chemical effects of the proceſs.*

* The remainder of this proceſs is a fine, white cake of ſalt, commonly called the *Sal enixum Paracelſi*; whoſe virtues and uſes are much the ſame with thoſe of *Tartarum vitriolatum*, for which it is frequently ſold.

the effect of the oil of vitriol in the present process, that this liquor is a kind of concentrated fire, as here producing the same change that a vehement fire did in the foregoing; excepting only, that a considerable part of the nitre in the present process remains fixed with the oil. At least the spirit of nitre it self appears to be of an igneous nature; since being mixed with the essential oils of cloves, carraway-seed, sassafras, or the like, it causes them instantly to flame, with a great explosive force.

## PROCESS CXXIV.

### *Exhibiting the method of preparing* Spiritus Nitri dulcis, *or the sweet spirit of* NITRE.

*The process.* 1. *TO a proper quantity of* Glauber's *strongest spirit of nitre, contained in a tall glass, first made hot, and placed under a chimney to carry up the pernicious fumes, carefully pour, by slow degrees, thrice its quantity of pure alcohol of wine; and immediately after every affusion there will arise a violent effervescence, with a considerable degree of heat; sparks of fire also frequently appearing to be generated in the struggle; and the grateful scent of green southernwood being diffused about the room. After the whole quantity of the alcohol hath been thus poured to the spirit of nitre, set the mixture to digest for the space of twenty-four hours or more, the longer the better, that the acid salt may be thorowly dissolved; and thus there will be obtained a dulcified spirit of nitre *; so called, as being deprived of its acrimony, and the power of dissolving silver.*

*The caution it requires.* 2. This process requires a great degree of care, to prevent its being prejudicial to the operator; but may be performed with much less danger, by using a weaker or more aqueous spirit of nitre, and only rectified spirit of wine; which being mixed together in the same proportion, and after the same manner, as above-mentioned, will have a gentler ebullition, and not cause that violent evaporation of the fluids concerned, tho they otherwise yield the same phænomena with the former.

*Virtues and uses of the production.* 3. By means of this process we obtain an acid *sal volatile oleosum*; the virtues whereof are truly admirable in all diseases, whether internal or external, attended with putrefaction. It is particularly excellent in case of the stone and gravel, being taken, with any proper vehicle, in the quantity of twenty drops, three or four times a day; and in this respect it was a gainful medicine to the famous *Sylvius*. 'Tis likewise good in such colics as proceed from a bilious, hot, or putrid cause; and one of the best medicines yet known in case of a gangrene or

* This spirit is usually ordered to be distilled from the mixture with proper degrees of fire, the juncture of the vessel being not luted at all, or but slightly; and this operation seems requisite to break the points of the salt-petre, and more effectually to dulcify or mitigate the spirit for internal uses.

sphacelation

ſphacelation. It may be ſafely given in caſe of a cancer, even tho deſigned for extirpation; for even then it will contribute to make a ſeparation of the corrupted from the ſound part whereto it is contiguous. Laſtly, it has, when properly applied, very great virtues, both in the ſmall-pox and plague.

## PROCESS CXXV.

### *Exhibiting the Regeneration of fixed* NITRE, *by means of fixed alkali.*

1. UPON *a proper quantity of* Glauber's *ſpirit of nitre, pour, by degrees, the lixivium of the fixed alkali of nitre, or, which is all one, oil of tartar* per deliquium, *and a violent effervеſcence will immediately enſue: continue thus pouring on the lixivium till the point of ſaturation is obtained, that is till the mixture ceaſes to bubble, or till it appears to be neither alkaline nor acid: then filtre the liquor, evaporate it to a pellicle, and ſetting it to ſhoot in the cold, it will run into cryſtals; which, if the point of ſaturation was nicely hit, cannot, in any reſpect, be diſtinguiſhed from genuine nitre.* *The proceſs.*

2. This is that noble experiment upon nitre, of which Mr. *Boyle* has wrote an entire treatiſe, under the title of the *Redintegration of nitre*; and certainly ſhews, that a mild neutral and innocent ſalt, at leaſt exceedingly like native nitre, may be generated from a known fixed alkali and ſtrong acid. It would, however, be too haſty to conclude from hence, that all nitre muſt needs be produced in this very manner; for the ſame ſalt may have different origins. Some there have been, who queſtion whether the ſalt thus obtained be really and truly nitre; but no ſcruple, methinks, need be moved upon that head; ſince by diſtillation with oil of vitriol, it undoubtedly affords the ſpirit of nitre. *Its uſe.*

## PROCESS CXXVI.

### *Exhibiting the regeneration of ſemi-volatile* NITRE, *by means of ſpirit of ſal-ammoniac.*

1. IF *inſtead of the oil of tartar in the preceding proceſs, the alkaline ſpirit of ſal-ammoniac, prepared with ſalt of tartar, be added, after the ſame manner, to ſpirit of nitre, the phænomena, upon continuing the experiment, will be the ſame; only the actually nitrous cryſtals, into which the liquor ſhoots, will be thinner and lighter, and, like ſal-ammoniac, ſemi-volatile.* *The proceſs.*

2. Hence we ſee that from the union of acids and alkalies, there may proceed ſalts retaining the nature of the body which affords the acid, but receiving their degree of fixedneſs from the alkali: thus from the ſpirit of allum, vitriol, *&c.* allum, vitriol, *&c.* may be procured. And *Its chemical phyſical uſe.*

as there are but two kinds of alkalies in all nature, *viz.* fixed and volatile, the nitre regenerated in this manner, will either be fixed or semi-volatile. If therefore we could conceive, that alkaline spirits may meet with the acid of nitre under ground, it were easy to imagine how nitre is there producible: but that this is ever really the case, seems hard to say. We see however, that it is possible for caustic alkaline salts to fix a caustic acid, and thereby form themselves into a neutral salt, that is neither acid, nor alkaline.

## PROCESS CXXVII.

### *Exhibiting the production of* NITRUM NITRATUM, *acid* NITRE, *or the impregnation of* NITRE *with its own spirit.*

*The process.* 1. *TO the filtred solution of nitre made in water, add a few drops of the spirit of nitre, sufficient to give a manifest acidity thereto; then evaporate the mixture to a pellicle, and in the cold it will shoot into perfectly nitrous crystals, but of an acid taste; which are the* nitrum nitratum, *acid nitre, or salt-petre impregnated with its own spirit.*

*Its uses.* 2. This process gives us a method of essentification, as it is called, or of saturating any kind of salt, or turning it acid, by means of its own spirit; and thus tartar, sea salt, *&c.* may be essentificated. But nitre treated after this manner has very few known uses; being remarkable for little more, when not made too sharp, than quenching thirst, and keeping the mouth cool and pleasant in burning fevers, being laid upon the tongue: tho it might likewise be properly employed in all putrid diseases: and in hot climates it will excellently serve to cool and refresh their liquors, so as to render them wholesom, and potable with pleasure.

## PROCESS CXXVIII.

### *Exhibiting the production of vegetative* NITRE, *or the preparation of* Glauber's *sal mirabile of* SALT-PETRE.

*The process.* 1. *IF after the distillation of* Glauber's *spirit of nitre, as mentioned in the hundred and twenty third process, the white, odd kind of salt, that remains at the bottom of the retort be calcined, and dissolved in water, the solution filtred, evaporated over the fire to a pellicle, and set in a cool place, it will shoot into an uncommon kind of crystals, that are not referable to any species of the known salts; being neither nitrous, vitriolic, nor of kin to sea-salt, but of a new nature, peculiar to themselves; and having this peculiar property, a wonderful tendency to chemical vegetation; whereby they form themselves,*

*selves, as it were, into a kind of trees, different from all the cryſtals of other ſalts; but approaching neareſt to the nature of* tartarum vitriolatum.

2. This experiment may be reckoned among ſuch as are contingent; for we cannot always produce theſe cryſtals, nor aſſign their preciſe figure before-hand. But if the diſtillation of the ſpirit of nitre be not long continued, or but juſt till the ſpirit is all come over, and the remaining mattter be then committed to a large veſſel, in a ſtill cool place, its upper ſurface will, like a fruitful ſoil, appear covered, in a wonderful manner, with a kind of cryſtalline vegetables; and if theſe cryſtals ſhould at any time be diſſolved or deſtroyed by heat, upon placing them in the cold again they will again begin to ſhoot, and give ſigns of vegetative life, ſometimes diſcoverable by the naked eye. *Odd effects thereof.*

3. If the ſalt of this proceſs be ever ſo often diſſolved in water, and ſuffered to ſhoot again, it forms it ſelf into the ſame kind of cryſtals it before appeared in; but becomes purer and purer by repeated operations. Its medicinal virtue is apertive, and differs not conſiderably from that of tartar of vitriol; the proceſs whereof we ſhall deſcribe hereafter. *Virtue of the preparation.*

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# Chemical History *of SEA-SALT.*

SEA-SALT appears to be every where contained in the water of the great ſeas, which being evaporated by the heat of the ſun in the hotter climates, leaves a parcel of dusky ſaline glebes, that is, crude ſea-ſalt, behind it. If this crude ſalt be diſſolved in about four times its own quantity of the ſame ſea-water, boiled, ſkimmed, decanted from its fæces, evaporated to a pellicle, and ſet in a cool place, it concretes into hollow, pyramidal cryſtals; which being again diſſolved, and ſeveral times treated as before, they at length appear in the form of a very dry and perfectly white ſalt, too well known to need any farther deſcription; this being the common ſalt that is uſed at the table. But if theſe depurated, dry cryſtals be put into a clean glazed veſſel, that is cloſe covered, and ſet over a clear fire, they will, for a long time, continue to crackle with a conſiderable noiſe, and loſe one third of their weight in the operation: and this is called the decrepitation of ſea-ſalt. If when the crackling ceaſes, and the ſalt is reduced to à greyiſh kind of powder, it be fuſed in a crúcible, then diſſolved in water, filtred and cryſtallized again, it becomes more pure and perfect than any other ſalt, well fitted for chemical operations, and exceedingly approaching to ſal-gem. And in this method we ought conſtantly to purify ſea-ſalt, for the uſes of chemiſtry; becauſe naturally it is always mixed with ſome impurities of the fiſhes, or other foulneſs of the ſea *Introduction to the hiſtory of ſea-ſalt.*

 which

which cannot be perfectly separated from it by any gentler or less laborious treatment. The sea-salt thus purified, is neither of an acid or alkaline nature; for it makes no effervescence with spirit of vitriol or oil of tartar. 'Tis wonderfully fixed in the fire, much more so than nitre, and will not flow without a violent heat; and then 'tis apt to run thro the pores of the containing vessel. Being calcined with the most intense degree of fire, it neither changes its nature, nor becomes the sharper; but it runs spontaneously in the air, by attracting the moisture thereof. There is this farther remarkable of it, that either directly or indirectly 'tis the only solvent of gold, mercury alone excepted; and powerfully dissolves it, if mixt with spirit of nitre, which is thereby turned into what we call *Aqua regia*, as being the menstruum for the regal metal. It preserves its virtues entire in passing thro' all the stages and circulations of the animal body, where nitre would be considerably changed. Lastly, it defends all the parts, both of animals and vegetables from putrefaction; so that theymay be preserved entire by its means for a long series of years. The like properties may also be understood of sal-gem, which appears to be the same kind of salt, tho found in a different form, and dug up in mountains, or mines, far distant from the sea.

## PROCESS CXXIX.

### *Exhibiting the preparation of* Glauber's *Spirit of* SEA-SALT.

*The process.*

1. T*O a proper quantity of purified sea-salt, dissolved in an equal proportion of fair rain-water, and put into a glass retort, pour, with care to avoid the noxious fumes, a weight of moderately strong oil of vitriol, equal to that of the sea-salt; and as soon as they mix together, a considerable ebullition, heat, and very piercing, prejudicial, and acid fumes will arise; which shew that the sea-salt is now volatilized. After this, apply a capacious receiver to the retort, and first distil off the insipid phlegm, with a gentle heat in sand, till the liquor just begins to rise acid; then pour away the phlegm, firmly lute on the receiver again, and distil with degrees of fire to the highest that can be given in sand: the spirit will rise in white fumes, as that of nitre does in red ones; and when no more liquor will come over, let the vessels cool, and carefully take away the receiver, which will now contain an excellent and genuine spirit of sea-salt* *.

*Observations thereon.*

2. Tho this spirit of sea-salt be a strong acid, yet it appears to receive nothing at all from the oil of vitriol in the operation; for it per-

* Spirit of salt is generally allowed good and genuine when it appears perfectly transparent, pellucid, or yellowish; when being new, its fumes immediately affect the nose agreeably; but when a year old, it loses its fine acidity and has no scent at all; lastly, when it is of an acid, pungent, saline taste, and neither corrodes nor tinges the cork whereby it is confined.

fectly

fectly diſſolves gold, eſpecially when obtained pure; which it will not do when mixed with oil of vitriol. The method of purifying it, when the caution of changing the receiver after all the phlegm is come over has not been obſerved, is to place it in a tall glaſs, and with a gentle heat exhale the aqueous part which will leave the ſpirit exceedingly ſtrong and pure. And, what farther proves it the real ſpirit of ſalt, if it be joined with fixed alkali, it will again be converted into ſea-ſalt; and if added to a volatile alkali, it becomes mere ſal-ammoniac: and therefore where-ever a clean ſpirit of ſea-ſalt is required, this is the kind that ought to be uſed, rather than that diſtilled with bole, which requires earthen veſſels, and a ſtrong and naked fire to raiſe it; the whole proceſs being conducted exactly as in the diſtillation of ſpirit of nitre; except that the ſea-ſalt ought to be thorowly decrepitated before it is committed to the retort: by which operation it will be found, that almoſt the whole body of the neutral, mild, and fixed ſea-ſalt is convertible into white fumes, that condenſe to an acid, corroſive, and volatile liquor. But if a third or fourth part of bole be not added to the ſalt before diſtillation, it will be fuſed by the fire, and made to paſs thro the pores of the glaſs.

3. The medicinal virtues of this ſpirit are very conſiderable, whether it be uſed internally or externally. Beſides the virtues it has in common with ſea-ſalt, and all the acid ſpirits, it is peculiarly adapted to excite the appetite in perſons of a weak or languid ſtomach. It likewiſe defends the body from alkaline putrefaction, clears it of viſcid phlegm, and is of ſingular ſervice in the ſcurvy: *Helmont* alſo commends it as the beſt known medicine, for the ſtone of the bladder and kidneys; a few drops thereof being taken every day in ſome proper vehicle. Externally applied, 'tis admirable in putting an immediate ſtop to gangrenes, or mortifications. It appears to be the beſt corroſive hitherto diſcovered, for taking off warts and ſmall cancers. I once performed an almoſt unexpected cure upon a man who had a little cancer in his tongue, only by frequently touching the part with this ſpirit. But I do not recommend it as a proper remedy in all kinds of cancers; only when they are ſmall, and unaccompanied with a bad habit of body. *Virtues and uſes of the production.*

## PROCESS CXXX.

### *Exhibiting the preparation of* Glauber's Sal Mirabile *of* SEA-SALT.

1. TAKE *the particular, white ſalt, that, after the preceding proceſs is finiſhed, remains at the bottom of the retort, bruiſe it, fuſe it for ſome time, at the fire in a crucible, then diſſolve it in water, filtre the ſolution, evaporate it to a pellicle, ſet it in a cool place, and it will inſtantly ſhoot into a beautiful and* *The proceſs.*

*and strange kind of crystals, of a figure not to be defined, and now commonly called* Glauber's *sal* mirabile *of sea-salt.*

*Old properties of the production.* 2. The figure of these crystals is so uncertain, that they scarce ever appear the same in any two operations, as Mr. *Boyle* has justly observed, in speaking to the differences he remark'd between salts. And this, he tells us, may well be owing to the quantity or different proportion of acid they contain, or according to the time at which the distillation of the spirit of salt ceased. And if, without a previous calcination, the *caput mortuum* be directly dissolved, filtred, *&c.* it may be made to afford an incredible variety of crystals, according to the quantity of the acid left behind, whereof it had not been freed by the fire: but if the proportion of the acid be much too great, it may entirely prevent the crystallization; in which case, the solution, and other parts of the operation must be repeated in order to get it out, before it is again exposed to crystallize. M. *Tournefort* tells us these crystals nearly resemble the strange kind which he observed hang pendulous from the top of a certain cave he met with in his travels. In some of their properties, they come nearly up to tartar of vitriol; but differ from it in others. They have this wonderful property, that being mixed with thrice their own quantity of wine, water, or any other similar liquor, and set at rest in a cool place for twelve, or twenty four hours, the whole liquor will appear to be frozen. And the same effect they produce with the liquor wherein the flesh of animals has been boiled. These several reasons induced *Glauber*, the first discoverer of this salt, to call it by the name of wonderful; and to give an entire treatise upon the subject thereof; wherein he likewise highly commends it as a menstruum, making it, in a manner, to be almost universal: and indeed its power is admirable in dissolving antimony and other metalline bodies, and extracting tinctures therefrom.

*Its medicinal virtues.* 3. This seems to be much the same kind of salt with that the *English* call by the name of *Epsom* salt, and of the like medicinal virtues; being indeed, when prepared pure, an excellent purgative; and may be taken in the quantity of an ounce, dissolved in water or other liquor, in the manner of the medicated salt of *Tachenius*; and when used along with a vehicle disposed to go off by urine, sweat, or insensible perspiration, it appears, more particularly, to promote and increase those discharges: but it ought to be used with discretion, because it is apt to damp, or totally abolish the power of generation.

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## PROCESS CXXXI.

### *Exhibiting the Regeneration of* SEA-SALT.

1. *TO a quantity of* Glauber's *spirit of sea-salt, obtained as above directed, pour, at several times, so much of the oil of tartar, made* per deliquium, *as will serve to saturate it, or till the mixture of the two ceases to make any ebullition, or effervescence, and tastes neither acid, nor alkaline, but entirely like the lixivium of sea-salt. The ebillition upon every affusion of the oil of tartar will be very considerable; and care must be had, by repeated affusions, made in small quantities, to hit the exact point of saturation; which being once obtained, the liquor will, upon all trials prove a real and proper lixivium of sea-salt. And if this liquor be filtred, or made pure, and evaporated over a gentle fire to a pellicle, and then exposed to the cold, it will there shoot into actual crystals of sea-salt; as appears plainly by their fixedness at the fire, their taste, figure, and the like; but principally by the power they give to* Aquafortis *of dissolving gold.* *The process.*

2. Here we see a third, neutral salt produced by the admixture of the violent acid of sea-salt; with a fixed alkali, as was before observed in the regeneration of nitre from its spirit; the regenerated salt participating neither of the acrimony of alkali, nor acid, when the operation is nicely performed, and the due proportion hit. Whence it appears, that in case a very sharp fluid were lodged in the human body, it might be corrected, or have its acrimony destroyed by an opposite salt, without causing any violent disorder; the salt compounded by this mixture being thus made harmless and inoffensive. But in such a case the new salt will partake of the nature of the acid, rather than the alkali; as we formerly observed of nitre, and as appears plainly in the present experiment. Whence we see the justness of that rule, which obtains among the adept, that acids determine alkalies. But tho 'tis manifest from this experiment, that sea-salt may actually be regenerated by uniting its spirit to a fixed alkali; yet will it not, according to the doctrine of some chemists, serve to prove in what manner sea-salt, or sal-gem, is originally, by nature, generated in the earth, or sea; because it seems impossible to say from whence such a quantity of fixed alkali should be supplied, as is requisite for this purpose; when not a single grain of it ever appeared to be the production of nature. *Its uses in chemistry, medicine, and natural philosophy.*

## PROCESS CXXXII.

### *Exhibiting the extemporaneous production of* Sal-ammoniac, *with the Spirit of* SEA-SALT.

*The process.* 1. MAKE *a gradual affusion of the spirit of sea-salt upon a proper quantity of the alkaline spirit of sal-ammoniac, prepared with salt of tartar, till all the ebullition ceases, and the mixture acquires the perfect taste and smell of a solution of sal-ammoniac. The phænomena in the operation will be the same as in the preceding process; and much the same caution is here required. Then this compound liquor being filtred, and evaporated to a pellicle, will form it self into starry* flocci, *having the scent, taste, odour, and volatility of sal-ammoniac; and being upon all chemical trials the same with that commonly sold in the shops, only purer.*

*Its uses.* 2. Here we see by compounding, as before we found by resolving sal-ammoniac, that it consists of a volatile alkali, joined to a volatilized sea-salt. We cannot however, with safety, from hence conclude, that fosil sal-ammoniac is actually produced in the same manner. This farther advantage we have from our present process, that it shews us how to render any given fixed salt volatile; namely, by first obtaining the spirit thereof, and mixing that spirit with a volatile alkali, as the spirit of urine for instance, then exhaling away the superfluous liquor, as mentioned in the experiment. And thus we can at pleasure turn neutral and alkaline salts into acid ones, and *vice versâ*, by distillation, and the making of proper mixtures. We have now gone thro' all the particulars necessary to the chemical knowledge of salts, excepting only the distillation of vitriol, which in strictness, is not a salt, but a semi-metal, and shall therefore be treated as such in its proper place *.

* Nothing of moment seems to have been omitted in this history of salts, unless it be the process for making *Aquaregia*; the menstruum generally used for dissolving gold and antimony. Those who please, may readily prepare this menstruum, by digesting strong spirit of nitre, with a fourth part of its own weight of pulverized sal-ammoniac, in warm sand, till a thorow solution is effected. The glass ought to be large, in proportion to the matter, and the heat but moderate, to prevent any ill effect from the bursting of the glass, or the fumes which are to be avoided. This liquor, when cold, ought to be kept in a glass, with a stopple of the same matter, or one made of wax.

CHE-

# Chemical History *of* SULPHUR.

*Introduction to the History of* Sulphur.

THE next thing to be treated in order, is Sulphur; which comes immediately after salts, and before we proceed to metals, because the first operation to be made upon metals, must be to purify and cleanse them from all heterogeneous bodies, of which sulphur is the chief; and so universally and intimately adheres thereto, that scarce any metal in nature is to be found without it, or can be perfectly freed therefrom.

Sulphur is a fossil body, friable in the cold, fusible, like pitch or bitumen, by a gentle heat, without taking fire of it self, insoluble in water, ardent spirit, and all the known acid liquors; tho it makes a most pernicious suffocating fume with oil of vitriol. It is very inflammable at a naked fire, and burns away in a blue flame; which is the constant nature of sulphur, and of which it can by no art be deprived. In its natural state it is wholly volatile, but proves neither acid nor alkaline upon any chemical experiment; tho a large quantity of acid matter may readily be obtained therefrom. But this no more proves it an acid, than a similar treatment would prove, that nitre and sea-salt are acids, because by the like means they may be converted into such. It is by the chemists, with some shew of reason, called the rosin of the earth; for all the properties which we formerly observed of rosins are likewise to be found in sulphur; excepting only, that it is not of it self, like all vegetable rosins, dissolvable in alcohol of wine. Some chemists have entertained a notion that sulphur may be fixed into metals; but this appears ill grounded: tho it must be confessed that it adheres closely, and seems intimately united to them; which are all brought to their proper form, by being separated and cleansed therefrom *. All the sulphur in use, is supposed to be dug from the earth; and large quantities of it are found in hot subterraneous places where the strong effects of fire are felt. For the other particulars relating to this mineral, we refer to the *Theory*.

* The truth seems to be, that all metals require a certain proportion of sulphur to make them what they are; the purer the less, and the more impure the greater. Metals too far freed of their sulphur, are *calces*; and when they abound too much therewith, brittle, foul; and unfit for working. When by too violent, or too long continued a fusion, the face of any metal happens to be burnt, that is, appears like a crust, and ceases to flow with the body thereof, the way to reduce it, and make it again flow smooth and equable, is to throw into it a due proportion of common sulphur: and when reduced to a mere calx, or glass, it may be made to assume a metalline form again, by fusing it in a sulphureous fire, or a fire of unctuous fewel.

## PROCESS CXXXIII.

### *Exhibiting the Sublimation of* SULPHUR, *or the way of purifying or converting it into Flowers.*

*The process.* 1. TAKE *any quantity of clean, native ſulphur, otherwiſe called* ſulphur vivum, *reduce it to a fine powder, mix it with an equal or double proportion of pure ſand, put the mixture into an iron or earthen retort, carefully lute on the receiver to exclude the air, and in a ſand-heat, give a ſtrong degree of fire; upon which the whole body of the ſulphur will melt and ſublime, or riſe in flowers, adhering to the ſides of the receiver, and retaining the nature and properties of native ſulphur; only ſulphur purified, and brought to the form of a meal, or flour.*

*Its nature and uſes.* 2. Care muſt be had in luting the juncture of the ſubliming veſſels, ſo as to exclude the air, the admiſſion whereof would inſtantly cauſe the matter to take fire, and make it ſuffocating; or unſafe to approach, for fear the veſſels ſhould break. This is the common method of purifying native ſulphur; which being fuſed again at the fire, and caſt into rolls, is the common ſulphur, or roll-brimſtone ſold in the ſhops. And if the ſublimation were ever ſo often repeated, the ſulphur would undergo no change; but ſtill retain its own nature, without being at all analyſed, or ſeparated into its component parts, only rendred volatile. Whence it appears, that ſulphur is a ſemi-volatile ſubſtance capable of enduring a ſtrong fire, and a high degree of fuſion, without changing its nature; being only purified by this operation, ſo as to become fitter for chemical and medicinal uſes: tho *Helmont* always preferred the native ſulphur to that purified in this manner, as having ſuffered no alteration from the fire, nor loſt its ſubtile ſpirit, in which, according to him, reſides its wonderful virtue: and on this account he highly commends it as an antipeſtilential medicine, ordering it to be given with ſalt and vinegar, and aſſuring us it was the great remedy of *Hippocrates*, in the cure of the plague. This is certain, that ſulphur is an admirable remedy for the itch, and all cutaneous diſeaſes; and may ſafely be adminiſtred in inflammatory or peſtilential caſes. But ſome have been ſo injudicious as to ſeek for the philoſophers ſtone therein; as if a thing ſo volatile as we find it in this proceſs, were very capable of being fixed, or tranſmuted into a pure metalline ſubſtance.

PRO-

## PROCESS CXXXIV.

### *Exhibiting the Analysis of* SULPHUR, *or the method of making* Oleum Sulphuris per campanam.

1. *MELT a proper quantity of the flour of sulphur, over a gentle fire, in a low, cylindrical, earthen vessel, of three or four inches diameter; when it is thorowly dissolved, place the containing vessel upon a wide glass dish, in a chimney, and set fire to the melted sulphur, so that its whole upper surface may appear on flame; then place the sulphur under a broad and large glass bell, suspended for the purpose, and first bedewed on the inside, and heated with the vapour of hot water, to prevent its cracking by the heat of the lighted sulphur. This bell is to hang so, that there must be the space of half an inch between its lower surface, and the edge of the vessel containing the burning sulphur, to give a free passage to the air; and if all things are rightly managed, the fumes of the burning sulphur, being now condensed by the sides of the bell, will trickle down, in the form of a ponderous, reddish, acid liquor, into the glass dish standing under the mouth of the bell: and this liquor is called by the name of spirit, or oil of sulphur,* per campanam. *And thus if the operation be duly continued, and the sulphur was exceeding pure, the whole quantity will be resolved into blue flame, and this acid spirit.* *The process.*

2. I have endeavoured to perform this process according to the different directions of all the chemical writers; but always without success, till I fell upon the method of M. *Homberg*; who for this purpose orders a very large bell to be made of a glass cucurbit, by cutting off a large part of its bottom in a circular form, with a diamond; so as to leave a very wide empty space. When this is done, he places the earthen dish, containing the sulphur, upon a clean glazed pan; but with some pieces of glass between to support and raise it above the pan, lest the oil that distills down into it should corrode the bottom of the dish externally, and so become impure. The cucurbit, when cut in this manner, he suspends at such a distance above the pan, as to give free entrance to the air; otherwise the sulphur, which ought to be kept continually flaming would soon be extinguished. And that it may be suspended with the greater convenience, he pastes a slip of linen cloth around the neck of the cucurbit, by means of starch and water; and in this linen makes convenient loop-holes for the string to run thro' that is designed to suspend it, and keep it firm. If during the operation the sulphur should happen to be extinguished, it must again be melted and treated as before. But sometimes when the flame seems almost expiring, the stirring of the matter about will alone recover it. And if it be thus kept stirring, so that the upper crust may be mixed and made to burn with the other matter, the whole body of the sulphur will be consumed, and no fæces remain behind; but if the sulphur were impure, or this caution neglected, there will be found *How best performable.*

found, at the end of the operation, a fixed bituminous ſubſtance, ſomewhat of a ſemi-volatile nature. Whence it is manifeſt, that pure ſulphur conſiſts of an inflammable and uninflammable part, or a perfect oil and an acid liquor, very like pure oil of vitriol: and this gives us the reaſon why the mixing of any kind of oil, properly ſo called, with oil of vitriol, forms a ſulphur, or bitumen. The operation is made to beſt advantage in a moiſt, quiet, and cool place below ground, or when the air is damp and cloudy. The fume which ariſes therein, ought ſollicitouſly to be avoided, as being poiſonous to all the animals that have lungs, which it violently conſtringes, and thereby ſtops the circulation of the blood, ſo that it ſuffocates the creature. The ſame, however, is wonderfully preventive of fermentation and corruption in natural bodies.

*Chemical and phyſical uſes of the proceſs, and production.* 3. This ſpirit has the power of diſſolving abundance of metalline and ſtony ſubſtances, and thereby of producing many vitriolic and bituminous bodies. From whence we may eaſily account for the origin of ſuch kind of bodies in the bowels of the earth. It differs but little from oil of vitriol, except that the latter generally contains ſome metalline parts; whereas, this appears to be a pure and univerſal mineral acid. And as this inflammable ſulphur is conſtantly found in vulcanos and fiery mountains, 'tis highly probable that their igneous and ſuffocating eruptions proceed either from this mineral, or the pyrites, which contains a large proportion of ſulphur.

*Medicinal virtues and uſes of the production.* 4. This oil of ſulphur is eſteemed the beſt acid we have for medicinal uſes; and preferable to oil of vitriol, on account of its purity. 'Tis thought excellent in burning fevers, and all other diſtempers proceeding from an alkaline cauſe. *Helmont*, in particular, commends it as a great preſerver of health, and tending to procure long life; a ſingle drop thereof being taken, with ſome proper vehicle, every morning upon an empty ſtomach.

## PROCESS CXXXV.

### *Exhibiting the manner of Diſſolving* SULPHUR *in fixed alkali.*

*The proceſs.* 1. T*AKE equal quantities of purified ſulphur, and good dry ſalt of tartar, grind them well together in a mortar, and put the mixture into a crucible; which, being covered with a tile to prevent the firing of the ſulphur, is to be ſet in an open fire, till the matter flows; upon which the ſulphur will inſtantly be diſſolved by the ſalt. Then take out the crucible, and ſuffer the matter to cool, and it will appear in the form of a red maſs of a particular odour; friable, and readily ſoluble in water, or capable of running by the moiſture of the air, or forming an oil of ſulphur* per deliquium, *and never to be reduced to ſulphur again.*

2. By

2. By this means sulphur is made so perfectly dissolvable in water, tho of it self it obstinately resists it, as thus to become potable, and fit for various uses. This method also furnishes us with a method of purifying metals from their sulphur; which is apt to render them brittle, and unfit for the hammer. Thus if any metal abounding with sulphur, be fused with a proper proportion, as suppose twice its weight, of fixed alkali, or salt of tartar; this salt will attract the sulphur, and thereby become of a red or gold-colour, and rise in the form of dross towards the top of the crucible; leaving the purified metal at the bottom: on which account this salt is, by the purifiers of metals, called a flux. And in the same manner we may presently find whether an ore, or unknown mineral substance, contains any sulphur, and in what quantity. The same experiment, likewise, affords us a key for discovering the cheat of those chemists who put off a tincture of sulphur prepared in this manner, for the tincture of gold; which it greatly resembles in colour. *Its uses.*

## PROCESS CXXXVI.

### *Exhibiting the manner of Dissolving* SULPHUR *in volatile alkalies.*

1. UPON *a quantity of purified sulphur, reduced to powder, or upon the flowers thereof, pour a suitable proportion of any oily, volatile, alkaline, animal spirit, as that of hartshorn, human blood, or the like; let them stand together in a close vessel for some time, and the spirit will gain a tincture from the sulphur, by dissolving a part thereof, which rises, like golden drops, to the top of the liquor.* *The process.*

2. From this experiment we may learn the action of sulphur in the body: for if it happens to find a volatile alkali there, it will presently be attracted, absorbed, and at the same time dissolved thereby, so as to stimulate the intestines, and cause them to discharge their contents; the scent whereof will then be exceeding fetid. And this property perhaps it is, that renders it serviceable in the plague, and other distempers proceeding from an alkaline cause. But in those diseases which are owing to an acid in the body, it seems to act no otherwise than by its weight, which may sometimes stimulate, tho its effects, in this case, generally prove insensible. *Its use.*

PRO-

## PROCESS CXXXVII.

### *Exhibiting the solution or tincture of* SULPHUR *in alcohol, by means of fixed alkali.*

*The process.* 1. UPON *a quantity of sulphur dissolved in fixed alkali, after the manner of the hundred and thirty fifth process, and reduced to a dry powder, pour a suitable proportion of pure alcohol of wine, and there will instantly be made a fine golden tincture of sulphur, which by standing, even in the cold, will gradually become deeper; and much more so, if the containing glass be shook. When this quantity of alcohol is impregnated with the sulphur, it may be poured off, and fresh put on, till it will no longer tinge it self upon the mineral; and by this means there will be obtained an actual and genuine tincture of sulphur.*

*Its use in chemistry.* 2. Many chemists have denied the possibility of extracting a true tincture of sulphur with spirit of wine; and indeed that spirit, unassisted with fixed alkali, cannot effect it by long digestion. But our present process shews us, that sulphureous bodies, once opened by fixed alkali, may readily be made into a tincture; and allows us to conclude, that whenever a mineral or metal, calcin'd with fixed alkali, gives a deep red tincture with alcohol, this tincture is owing entirely to the sulphur adhering to the metalline or mineral body. Had the Elector of *Cologn* understood this, he would never have paid so generous a price to that subtile alchemist who put such a tincture upon him for *aurum potabile*; tho, the better to carry on the cheat, he actually employed some gold in the preparation, which he could easily recover again. The method it self we have formerly hinted, and in short was this: he took gold, antimony, and salt of tartar, and fused them together; then, after the mass was cold, he poured alcohol upon it, which immediately drew out a tincture, in all respects, like that of our present process; the sulphur of the antimony being here alone dissolved by the menstruum; for which purpose it was previously opened by the salt of tartar; the gold remaining all the while untouch'd. And this is the foundation and origin of all the red tinctures hitherto prepared from metals.

*Medicinal use.* 3. All the sulphureous tinctures obtained in this manner, are very drying, healing, dissolving, and aperitive; on which account they may properly enough be given in such distempers as proceed from cold, aqueous causes, and where the fluids are mucous or too viscid. Dr. *Willis*, indeed, commends them in phthisical cases; but they seem too hot and drying for that purpose, especially if an ulcer be actually formed in the lungs.

PRO-

## PROCESS CXXXVIII.

### *Exhibiting the manner of making Syrup of* SULPHUR.

1. D*Issolve of sulphur, incorporated with fixed alkali, after the manner of the hundred and thirty fifth process, in about eight or ten times its own weight of fair water; filtre the warm solution, and boil it up to the consistence of a syrup, with an equal, or a double weight of sugar.* *The process.*

2 This experiment shews us a method of rendring sulphur potable; and at the same time instructs us in the nature of the lixiviums to be gained by means of fixed alkali from metals; and the method of purifying ores or metalline glebes. If pure sulphur, without addition, were, for years together, to be digested or boiled in water or alcohol, it would never be dissolved thereby: but if it is first fused with salt of tartar, it readily affords a high tincture, or rich solution, with them. And all the tinctures gained from metalline substances, first fused with fixed alkali, are of this kind; not that the menstruum, as some would have it, draws out the sulphur of the metal; but only dissolves the external sulphur, which is always apt to cleave thereto. In like manner, when any metalline glebe or ore is to be purified, and reduced to the form of metal, the usual way is first to roast or torrefy it, then grind it to powder; and lastly, either to fuse it, as we lately mentioned, with thrice its weight of fixed alkali, which incorporating with the light, sulphureous part of the ore, leaves the heavier metal at the bottom of the crucible; or else, after the manner of the present process, to boil it in a strong lixivium of quick-lime or salt of tartar, which will likewise dissolve away the sulphur from the metalline part. *Its uses.*

3. This syrup of sulphur was Dr. *Willis*'s pectoral, or great secret for coughs; which he highly commends even in case of the phthisic and ulcerated lungs: but, like the tincture of sulphur before-mentioned, it is very desiccative as well as healing to the body; and therefore seems only proper for this distemper in moist, cold, or phlegmatic habits, or when it proceeds from defluxions, catarrhs, or such kind of causes. I have often used it, however, in these cases, but could never observe any considerable effects it produc'd: which possibly may be owing to the difference of climate, or constitution of the inhabitants, between *England* and *Holland*. But I should never employ it in hot distempers, dry coughs, ulcerated lungs, and asthma's; as believing it, in these cases, very prejudicial. It may, perhaps, be made more pectoral, and fitter for some purposes, by using syrup of hyssop, instead of sugar, in its composition. *Medicinal virtues of the production.*

## PROCESS CXXXIX.

*Exhibiting the solution of* SULPHUR, *or the preparation of its Balsam, with expressed oils.*

*The process.* 1. *TO one part of the flowers of sulphur, put into a large, glazed, earthen pot, add three or four parts of oil-olive, gained by expression, or any other expressed oil whatsoever, and boil them together over a soft fire, for the space of an hour, or till the sulphur, which is apt to remain in fusion at the bottom, be totally dissolved and united with the oil into a red balsam, called by the name of* Helmont's *balsam of sulphur.*

*Its uses.* 2. Here we see that sulphur is readily dissolvable in gross oils; which shews the general method of preparing the balsams thereof; and gives us another method of separating ores or metalline bodies from their external sulphur. Thus antimony, for instance, being reduced to powder, and boiled in oil, will be freed of its sulphur, which is now formed into a balsam. And this may be sufficient to let us see, that all the balsams gained after the same manner from metals, are no more at bottom than balsam of sulphur; being very improperly called the balsams of the metals from whence they were gained.

*Medicinal virtues of the production.* 3. This balsam is recommended both for external and internal uses, as being warm and mollifying in case of wounds, sanious ulcers, fistula's, *&c.* and curative even of ulcers in the lungs. *Helmont* particularly crys it up in all diseases of the breast. But I cannot at all approve of it as an internal medicine; because it is certainly of a very disagreeable taste, and leaves such a nauseous impression upon the tongue as is hard to be got off again. Besides, the oil it is made of being very gross, it may be apt to cause obstructions in the lungs: and I have frequently found, that upon giving this kind of balsam in phthisical cases, the fever and other symptoms have been increased, and the appetite depraved. But as an external remedy, it is doubtless very serviceable in wounds, ulcers, *&c.* which seems to have given the occasion of its being likewise applied as an internal in similar cases.

## PROCESS CXL.

*Exhibiting the method of dissolving* SULPHUR *in distilled oils, or of preparing* Balsamum Sulphuris terebinthinatum.

*The process.* 1. *TO a proper quantity of the flower of sulphur, put into a tall glass, pour four or six times its own weight of fine æthereal oil of turpentine, and boil them together for the space of eight hours; during which time a large part of the sulphur will dissolve with an audible noise; but not so*

*readily, nor in ſo great a quantity, as if it would in an expoſed oil; a conſiderable portion remaining, like melted pitch, at the bottom of the glaſs, utterly incapable of being intimately joined with the oil. The clear ſolution, being poured from the undiſſolved ſulphur, is called* Balſamum ſulphuris terebinthinatum; *which, by long ſtanding in the cold, will alſo let fall ſome part of the ſulphur before ſuſpended therein.*

*The doctrine it affords.*

2. We ſee, therefore, that the groſs, ſmooth, or moſt unactive oils are more capable of making a ready and thorow ſolution of ſulphur, than the ſharp and ſubtile; ſo that alcohol, which is an oil exceedingly ſubtilized, will not touch it at all; whilſt it readily unites with the thick, heavy oils, gained by expreſſion, as that of linſeed, for inſtance. Whence we may lay it down as a rule, that this kind of ſolution is according to the denſity of the menſtruum employed.

*Medicinal uſes of the production.*

3. This balſam being wonderfully hot and penetrating, ought to be uſed with caution; or only in cold and aqueous caſes or conſtitutions. When given internally, it operates with great expedition; as is manifeſt by the change it preſently makes in the colour and ſcent of the urine and ſweat. A few drops thereof, drunk in a glaſs of wine, will immediately give a ſcent of violets to the urine. But I prize it more as the product of a chemical experiment, than as a medicine; becauſe we have always ſome miſchief to apprehend in the body from thoſe fat ſubſtances which are able to make a ſolution of ſulphur. On which account it is ill judged of ſome chemiſts to recommend this balſam, before all other medicines, in the cure of the ſtone or gravel; tho it muſt be acknowledged diuretic and aperitive. But if there be any inflammation in the bladder or kidneys, or any tendency to a fever, it may prove very prejudicial; and in contrary circumſtances perhaps as ſerviceable. This is certain, that it may be externally uſed with much greater ſafety than internally. It is a good dreſſing for foul, ſanious ulcers, in tendinous or nervous parts of the body; being applied warm. But here alſo it will prove pernicious in caſe of inflammation.

*Ways to vary and improve it.*

4. The different ſolutions of ſulphur are readily convertible into various kinds of balſams, by mixing with them the eſſential oils of particular vegetables, to take away their natural odour, and give them a new one; from which alteration they generally receive their names. Thus aniſated balſam of ſulphur is made by adding ſo much eſſential oil of aniſeeds thereto, as may give it the predominant ſmell and taſte thereof. And the like addition may be made of the oils of amber, cloves, &c. ſo as to form balſams of ſpecific qualities and virtues. Or the like may be done by originally diſſolving the ſulphur in proper medicated oils, prepared by infuſion, coction, diſtillation, or otherwiſe, from ſuitable ingredients, in the manner of our preſent proceſs.

## PROCESS CXLI.

### *Shewing the method of dissolving Balsam of* SULPHUR *in alcohol.*

*The process.* 1. *TO the terebinthinated balsam of sulphur of the preceding process, add thrice its weight of alcohol, and by strongly shaking the containing glass, they will presently mix into an alcoholizated balsam of sulphur; a small proportion of the sulphur afterwards falling to the bottom. But by long digesting them together, the sulphur will intimately unite with the alcohol, and the oil of turpentine sink to the bottom of the vessel.*

*Its use.* 2. Hence we are furnished with another method of dissolving sulphur in alcohol; and by that means of drawing sulphureous tinctures with it from antimony, and other semi-metals; namely, by boiling them first in oil to extract their sulphur, which may afterwards, by digestion, be taken up with a pure inflammable spirit.

*Medicinal virtues and uses of the production.* 3. This balsam is greatly commended in all sanious and purulent ulcers; or where matter ought presently to be discharged, or its afflux to be stopped; as in all wounds of the nerves, tendons, joints and lymphatics. A few drops thereof, applied hot, will dry up the humors, and give strength to the part. It is likewise successfully used in large gun-shot wounds, fistula's, *&c.* and powerfully prevents gangrenes or mortifications.

## PROCESS CXLII.

### *Exhibiting the preparation of the Soap of* SULPHUR.

*The process.* 1. *IF, instead of the oil-olive used in the common preparation of soap, the balsam of sulphur prepared either with expressed oil, as in the hundred and thirty-ninth, or oil of turpentine, as in the hundred and fortieth process, be boiled up to a due consistence, with the strong lixivium of salt of tartar, there will be obtained an intolerably fetid and fiery soap.*

*Its use.* 2. These soaps, tho cried up as an universal medicine by *Helmont*, who first prepared them, and *Starkey*, are by much too sharp, caustic, and nauseous for internal use; whence I am inclined to think they neither of them had any experience of their virtues. For my own part, I cannot heartily recommend the internal use of sulphur, in any quantity, after what manner so ever it is prepared. The chemical use, then, of this experiment, is to shew that fossil sulphurs are reducible to soaps.

PRO-

## PROCESS CXLIII.

### *Exhibiting the Generation of* SULPHUR *from oil of vitriol and oil of turpentine.*

1. *WITH a proper quantity of oil of turpentine, put into a cucurbit, carefully, and by ſlow degrees, mix an equal weight of ſtrong oil of vitriol; the veſſel wherein the mixture is made being firſt heated and placed in a chimney, to carry up the noxious fumes: a great ebullition, and conſiderable degree of heat, will enſue upon every affuſion, with a copious, red fume; and ſometimes even the flame of ſulphur. When the whole quantity of oil of vitriol is poured on, and the ebullition ceaſed, gently diſtil the mixture in cloſe veſſels, and a ſand-heat, and there will come over an oil exceedingly like* petroleum; *a black, pitchy, or bituminous ſubſtance remaining at the bottom of the retort, fuſible by heat, brittle in the cold, burning away in a blue flame, and both in taſte and ſmell like ſulphur. And if this bituminous matter be carefully dried, and urged with a ſtronger fire, it will ſublime into true, yellow, inflammable ſulphur; but more fetid than the natural.* *The proceſs.*

2. The mixture of the two oils requires a good deal of caution; for if too large a quantity, or more than a few drops, be poured on at once, it might endanger the breaking of the veſſel, the firing of the liquors, and, by the fumes they afford, the ſuffocation of the operator; the mephitical exhalations in this operation being near of kin to thoſe of the *Grotta de cani*, not far from *Naples*. The diſtillation, likewiſe, requires to be made with care; leſt the matter, by blocking up the neck of the retort, ſhould occaſion the veſſels to burſt; or the lute cracking and admitting the air, ſhould ſet the matter on fire. *The Cautions to be obſerved in it.*

3. This experiment does not only ſucceed with oil of turpentine, but alſo with any other vegetable oil, or unctuous matter; whence we may draw this general concluſion, that any ſtrong mineral acid, mixing with any fat or unctuous vegetable, will form a bituminous or ſulphureous ſubſtance. And in this manner probably it is, that ſulphureous and bituminous bodies are formed in the earth; the univerſal mineral acid being ſometimes mixed with petroleum, and ſublimed in proper caverns by the ſubterraneous heat. This is certain, that as by reſolution we formerly found ſulphur diviſible by fire into a combuſtible oil, and an uninflammable acid ſpirit; ſo now by compoſition we find it may be made by the joint union of a vegetable oil and a mineral acid. *The doctrine it affords.*

PRO-

## PROCESS CXLIV.

### *Exhibiting the Generation of* SULPHUR *from oil of vitriol and alcohol.*

*The process.* 1. *TO one part of strong oil of vitriol, put into a warm glass retort, and set under a chimney, carefully, and by small quantities at a time, add thrice its weight of alcohol; and when the heat, ebullition, and noxious fumes occasioned by the mixture are ceased, shake the glass, and distil the liquor with a gentle heat into a capacious receiver; the juncture of the vessels being well closed. Upon this, the whole place will immediately be filled with the sweet scent of the male southernwood, which however is afterwards very suffocating and offensive to the lungs; in the mean time there will come over into the receiver a sweet spirit of vitriol, but of a strong sulphureous suffocating odour; leaving a black, pitchy, bituminous matter behind it, which in every respect appears to be sulphur; and accordingly, by a stronger heat, will sublime into flowers.*

*The caution it requires.* 2. Great caution is to be used in this as well as the former process, to avoid the noxious fumes, which so contract, or otherwise affect the lungs, as to prove suffocative, or cause a violent coughing that cannot in a short time be stopped.

*The production what.* 3. The liquor that comes over in this process seems to be the sweet spirit of vitriol, or *Lully*'s water, the fragrancy whereof is so much talked of by the ancient chemists; for if it be distilled in any considerable quantity, its scent will be diffused all around to a great distance from the house where the operation is performed. Whence it is by some of them said to draw the birds of the air together by its odour.

*Use of the process.* 4. The operation it self informs us, that a very subtile oil, such as pure alcohol is, may by means of an acid be converted into actual sulphur; which therefore cannot with any colour of reason be expected to contain, or be readily convertible into metal.

## PROCESS CXLV.

### *Exhibiting the preparation of* Lac Sulphuris.

*The process.* 1. *IF any acid liquor be mixed with the tincture of sulphur, prepared with fixed alkali and alcohol, in the manner of the hundred and thirty seventh process, its red colour will immediately be changed to white; and upon this, a substance will be precipitated to the bottom of the vessel, which when washed in water and dried, is by the chemists called* Lac Sulphuris, *or the magistery of Sulphur.*

2. The

2. The experiment will likewise succeed in an aqueous solution of sulphur, first united by fusion with fixed alkali; and many chemists have strangely pleased themselves with such a preparation, considered as a medicine; imagining that nothing could withstand its force. But the principal use we make of the process, is to shew that all sulphureous fossils, opened by alkalies, or dissolved in sulphureous menstruums, may presently be turned white, and precipitated by acids. And this is also the case in the red tinctures gained from metalline or other mineral bodies; as particularly in the deep tincture of antimony, which may thus instantly be turned white, and have its sulphur thrown down to the bottom of the containing vessel. *Its use.*

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# CHEMICAL HISTORY *of* METALS.

THE treatment of metals ought, in a just and methodical course of chemical operations, to precede the treatment of semi-metals, as being much more simple and tractable than they; for semi-metals are a mixture of heterogeueous parts along with such as are truly metalline. And therefore, in order to know what metal they contain, we must first be brought acquainted with metals themselves: an ample description whereof, with all that relates to their purification, and fitting for chemical uses, we have formerly delivered in the second part, or *Apparatus*; to which, therefore, we here once for all refer, to shorten the remaining part of our business, instead of repeating the like account at the head of the separate history of every metal. *Introduction to the history of Metals.*

# CHEMICAL HISTORY *of* IRON.

WE shall begin our chemical examination of metals with *iron*, because this, of all the number, approaches the nearest to a vegetable nature, and is most manageable; as may appear from the facility and readiness wherewith it dissolves, and becomes one with other bodies. And in the same order we shall go on with the rest of the metals, according as they approach nearest to this in their nature, or easy and commodious manner of treatment; which being here observed once for all, will save us the trouble of frequent repetitions, that might otherwise be necessary to keep the reader in mind that we still proceed in the same geometrical method hitherto followed. *Introduction to the history of Iron.*

## PROCESS CXLVI.

### *Exhibiting the preparation of the* Vitriol *of* IRON.

*The process.* 1. *UPON a quantity of clean and bright filings of iron, placed in a convenient glass vessel, first made hot, to avoid its breaking, pour an equal or a double weight of strong oil of vitriol, and no remarkable effervescence or solution will ensue; but proceed to add gradually about three or four times as much warm water as there were filings of iron employed, and immediately a strong ebullition and a considerable heat will arise, together with a smell of sulphur or garlick, like that observable in mines, or particular mineral waters; and thus a perfect dissolution of the metal may gradually be effected. About which time, the liquor is not acid, but of a sweet, vitriolic, or styptic taste; the sharpness of the oil of vitriol being quite destroyed by the metal. But if any considerable quantity of the iron should remain undissolved at the bottom, a few more drops of oil of vitriol may be added; and on the other hand, if the solution should be total, it will be proper to add a little more filings, to prevent any predominating acidity of the oil of vitriol. When the solution is thus nicely adjusted, the green-coloured liquor is to be filtred and evaporated to a pellicle, over a gentle fire; after which, being set in the cold, it will shoot to the bottom and sides of the vessel, in the form of green, transparent crystals, called by the name of sugar, magistery, salt, or vitriol of iron; being fusible at the fire, and perfectly dissolvable in water.*

*Its nature and use.* 2. This is the general method of rendring metals potable, or calcining them by moisture, as it is called, and gaining their vitriols; which appear to be no other than the metals themselves, united with a certain proportion of acid and water, and thereby formed into transparent crystals. And it is remarkable, that they all, in dissolving, smell strong of sulphur: from whence we may have a criterion for judging of the success of mineral waters, when drank medicinally; for if upon taking any quantity of the chalybeate water of a medicinal spring, the eructations should have the smell of sulphur, it will be a plain indication that there is some acid humor in the body, which makes a solution, or mixes with the iron in the water; and consequently, that the drinking of such water is likely to cure the distempers producible by such an acid. It is also very remarkable, that if this process be performed in a tall glass, the fumes which ascend to the mouth thereof will readily take fire at a candle, and go off like gun-powder, with flame and explosion.

*Virtues and uses of the production.* 3. The vitriol of our present process is the basis of all the black kinds of ink, and esteemed an excellent diuretic and aperitive medicine, and a great destroyer of worms in the first passages. Its medicinal virtues it has partly from the metal, and partly from the acid of the vitriol. When taken in a considerable dose, it proves purgative, and if in a larger vomitive. Dissolved in a large proportion of fair water, as

as in the quantity of a grain to a pint, it ſo perfectly reſembles thoſe of the *Spaw*, as ſcarce at all to be diſtinguiſhed from them, eſpecially if mixed with a drop, or leſs, of oil of vitriol. But if it be mixed in too large a quantity with the blood, 'tis apt to coagulate and turn it black; as alſo to render the ſmall fibres of the body dry and criſpy: on which account it is an excellent ſtyptic, corroborating, and deſiccative medicine, when properly uſed. But if it be made with too large a proportion of the acid, it may become prejudicial when uſed internally. In ſome caſes we find that crude iron is a ſafer, and more effectual medicine, than when joined with acids; as particularly in the green-ſickneſs and the like. *Helmont* obſerves, that all ſuch peripneumonical perſons as make uſe of vitriolic waters, die; the vitriol turning to oaker in their bodies; and the water taken along with it coming away clear: oaker being nothing elſe but the calx of iron. Hence we may learn, that when any chalybeate waters depoſite a yellow ſediment, they are no longer fit for uſe; as having now loſt their moſt medicinal part.

## PROCESS CXLVII.

### *Exhibiting the peparation of* Ludovicus's *Tincture, or potable Vitriol of* IRON.

1. *TAKE equal quantities of the pure vitriol of iron, and cryſtal tartar, reduced to powder; boil them together in an open glazed veſſel, with twenty times their own quantity of fair water, to the conſiſtence of honey; then put this thick maſs into a tall glaſs, and pour upon it about twelve times its weight of ſpirit of wine, once rectified, and boil them together for four and twenty hours, or longer, and there will appear on the top a red tincture, which, being decanted from the fæces, is* Ludovicus's *tincture, or potable vitriol of iron.* *The proceſs.*

2. The experiment ſhews us a method of uniting vegetable with metalline ſalts; in which, when the metalline ſalt is obtained by means of an acid, it is requiſite that the vegetable ſalt ſhould likewiſe be acid. *Its uſe.*

3. This tincture of iron, which has its name from *Daniel Ludovicus*, who deſcribes it in his treatiſe of pharmacy accommodated to the modern practice, is, we ſee, a ſolution of the vitriol of iron, and the body of tartar, in ſpirit of wine; and therefore an admirable ſtimulating, aperitive, detergent, and relaxing medicine; good to cleanſe the firſt paſſages, and to deſtroy worms therein; being taken in the quantity of ſixty drops, with a glaſs of *French* wine, upon an empty ſtomach, and the doſe repeated at the diſtance of an hour or more. It is likewiſe ſerviceable in too great a laxity of the fibres, in the ſcurvy, a beginning dropſy, weakneſs in children, and particularly in the rickets. It may alſo be uſed with ſafety and advantage in leucophlegmatic habits, *Virtues and uſes of the production.*

 the

the green-sicknefs, hysterical and hypochondriacal disorders, and the various kinds or degrees of the jaundice. In strong constitutions, it may be taken in the quantity of two or three drams for a dose; drinking some convenient liquor at the distance of half an hour after it. And thus it may be continued for two or three weeks together, the patient using proper exercise, as riding, walking, or the like; by which means it will be made to act as a purgative, and turn the excrements black. And it has this advantage to recommend it, that it is not apt to be precipitated into an astringent calx, or crocus in the body. In short, it may be used to advantage in all those cases where the preparations of iron are proper. The best way of preserving it for this purpose, is to keep it upon its own fæces, and pour it off from them by a gentle inclination of the vessel, at the time of using it; because, by standing thus, it daily dissolves more of the metal lodged in the fæces, so that the older it is the better it becomes. It is a caution proper to be observed during the time it is used, to refrain from taking alkaline spirits, as spirit of hartshorn, or the like, which might prevent the effect thereof.

## PROCESS CXLVIII.

### *Exhibiting the reduction of the* Vitriol *of* IRON *to a Calx or Crocus; or the preparation of* Crocus Martis astringens.

*The process.* 1. TAKE *any quantity of vitriol of iron, gently dried and reduced to powder; put it into a clean crucible, and expose it to a soft fire, that only the aqueous part thereof may exhale; upon which the vitriol will lose its green colour, and begin to grow opake and white; and, being removed from the fire, and preserved in this state, it is called the white calx or powder of iron. Upon increasing the heat, the matter will fuse, and, when cold, turn to a solid, greyish mass; which is likewise called iron, or the vitriol of iron, calcined to whiteness. Increase the fire again, and keep the matter stirring till it entirely ceases to yield any fumes at all; the lighter acid it self being hereby driven off, it will now be reduced to a perfectly dry, red powder, called the red calx of iron, or* Crocus Martis astringens.

*Its nature.* 2. The production of this process is likewise called by the *Arabic* word *Colcothar*, which signifies the same with red calx, being the most violent astringent obtainable from iron; a portion of the heavier acid of the oil of vitriol still remaining united to it, notwithstanding the strong fire that acted upon it in the operation; from whence proceeds its great stypticity. But if the calcination be very long continued, with a violent fire, so as to drive off all the acid parts adhering to the matter, it will at length be reduced to iron again.

*Uses.* 3. From hence we see, that metals brought by solution, or liquid calcination, as 'tis called, into the form of vitriols, are fusible with a small

degree of heat; when, losing their aqueous parts, they at the same time lose their transparency, and become white or grey. Whence it may plausibly enough be conjectured, that the transparency of such crystals depends upon the water they contain; or that they actually require a certain quantity of aqueous matter to make them what they are. This likewise furnishes us with a method of reducing metals to powder, and afterwards of converting that powder to metal again, by means of nothing but heat and acid. And as in this operation, the longer the matter is detained in the fire, whilst any acid remains mixed therewith, the redder and stronger it becomes; this shews us how bricks ought to be managed in the kiln, to make them durable, and give them the colour most pleasing to the eye; for 'tis the iron they contain that makes them turn red in the burning. Our process, likewise, lets us into the nature and generation of the rust of metals; for these being exposed to the action of the air, and the acid particles which continually float therein, their surface will necessarily be corroded by them, and turned into a vitriolic substance; which afterwards, by the action of the sun, or of the warm air, being deprived of its acid, a calx or rust is of course formed upon the surface of the metal.

4. This colcothar, or calx of vitriol thus obtained, is of a wonderful styptic virtue, and will instantly stop all kinds of hæmorrhages; being applied, upon a little cotton, to the mouth of the ruptured vessel, which it immediately purses up, coagulates the blood in contact with it, and strengthens the part. And on this account it is succesfully used in sanious ulcers, attended with a large flux of matter, or fungous flesh; being mixed, in a moderate proportion, along with other materials. *Medicinal virtues and uses of the production.*

## PROCESS CXLIX.

### *Exhibiting the method of running* IRON *into oil; or of preparing* Oleum Martis, per deliquium.

1. EXPOSE *the red calx of iron, in an open glass dish, to the moist, external air, and it will run* per deliquium *into a gross, thick, unctuous, and exceeding red liquor, or kind of oil, consisting of the acid of vitriol, the body, of iron, and the aqueous particles of the air.* *The process.*

2. This is a general method of obtaining the oils of metals, or of converting their substance into what we commonly call by the name of oil; the rationale whereof, tho it may at first appear very difficult to assign, is no other than this. The most fixed and dry part of the acid of the oil of vitriol, remaining in the calx of the metal, being no less attractive of moisture than the fixed alkali of vegetables, readily imbibes the aqueous humidity of the air, by which it is dissolved, and made again to act as a menstruum upon the metalline part of the calx. But as the air contains numerous other particles, as well as such as are *Its rationale.*

 aqueous,

aqueous, those also sometimes mixing with the calces of metals thus exposed, will effect surprizing alterations therein, perfectly change their nature, and make them volatile; especially if the operation be frequently repeated, by drying the solution, and exposing the powder again to the action of the air, which thus greatly opens and volatilizes the body thereof.

*Virtues of the production.* 3. This oil is a greater styptic, escharotic, and astringent, than the calx of iron it self, prepared in the manner of the preceding process; and may be used much after the same way, to answer the same purposes.

## PROCESS CL.

*Exhibiting the preparation of* Basil Valentine's *golden Tincture of* IRON, *with the dulcified spirit of sea-salt.*

*The process.* 1. *If upon the oil of the preceding process, again reduced by inspissation to a calx, or the red calx or crocus of vitriol* per se, *three or four times its quantity of the sweet spirit of sea-salt* * *be digested for a while, in a tall glass, a golden or true metalline tincture will thereby be produced; the calx it self remaining undissolved at the bottom.*

*Its nature.* 2. This tincture is exceeding rich in the virtues of iron; on which account, it is said by *Tachenius* to contain the true sulphureous soul of that metal. The smallest proportion will make a black, atramentous liquor with the tincture of galls; which shews how richly it is impregnated with iron: yet, which is strange, almost the whole body of the metal remains untouched by the menstruum. *Basil Valentine*, the author of this tincture, who has treated largely thereof, observes that the astringent crocus of iron is totally dissolvable in strong spirit of sea-salt; but gives out only its soul in the dulcified kind of that spirit. This is certain, that whatever be the tinging matter, a gold-coloured tincture is actually produced: and in the same manner a tincture may be drawn from gold, first dissolved, reduced to a vitriol, and calcined; the noble metal losing nothing but its colour in the operation. And one might be tempted to believe, that this golden tincture of iron was really the *aurum potabile* of the antient chemists; of which they write in this concealed manner. "Join me to my sister, and the effect of our conjunction will be a green offspring, a hermaphroditical stone, of which, by means of salt, may be made a golden tincture, or potable gold." Which seems plainly to denote the formation of green vitriol from

* The sweet spirit, as it is called, of sea-salt, is prepared with spirit of sea-salt, in the same manner as the sweet spirit of nitre is from strong spirit of nitre; *viz.* by mitigating and digesting, or distilling it with spirit of wine, in the manner of the hundred and twenty-fourth process.

iron

iron and oil of vitriol, which vitriol, with spirit of salt, affords us the tincture of our present process.

3. This golden tincture of iron has great medicinal virtues; a few drops of it being taken upon an empty stomach, in a glass of *Spanish* wine, has wonderful effects in cases of worms, and weak viscera. It strengthens a weak stomach, gives tensity to the relaxed fibres, cleanses the *primæ viæ*; and when the body is languid and unactive, acts powerfully as a stimulus, and quickens the motion of all its parts: scarce any thing in nature being more friendly to the human body, more conservative of all its powers than iron, or more preventive of the diseases whereto 'tis subject. *Medicinal virtues of the production.*

## PROCESS CLI.

### *Exhibiting the Solution or Tincture of* IRON *in* Rhenish *wine.*

1. UPON *a parcel of clean and bright filings of iron, pour about twenty times their own weight of good* Rhenish *wine, and boil them gently together, in a tall glass, till they communicate a black tincture, and the wine acquires a sweetish styptic taste, which is then to be poured off clear, and filtred for use.* *The process.*

2. When the tincture is once poured off from the undissolved part at the bottom, if fresh wine be put on, and the process repeated in the same manner as before, the menstruum will not now be so much impregnated as the former: whence this wine extracts a tincture without actually dissolving the metal. The like tincture may also be obtained by letting the menstruum stand upon the filings, in the cold, for the space of three or four weeks, the containing vessel being shook between whiles; or till the tincture becomes sufficiently black and rich. *Its nature.*

3. This process shews, that iron is of such a nature as readily to join it self with the mildest vegetable liquors; and being thus divided into exceeding small parts, and intimately united with them, it is no wonder if we find this metal in the bodies of plants, animals, and minerals; as it has lately, by particular experiments, been discovered in the ashes of such bodies. *Uses.*

4. The present tincture is the best and most efficacious medicine of all those obtained from iron; being almost infallible in all those diseases which proceed from mere laxity of the fibres, or coldness, sluggishness, or inactivity of the juices. In effect, it will actually cure all the distempers that are curable by chalybeates. It may be taken in the quantity of half an ounce for a dose, twice or thrice in the day, according to the strength of the patient, at such times as the stomach is most empty. I have my self cured many desperate cases by means of this single remedy; and indeed it is capable of affording any man a comfortable subsistence, if it were handsomely and judiciously disguised, as perhaps it might be with a proper colouring, aromatics, and *Medicinal virtues and uses of the production.*

some saccharine substance, to render it pleasant and agreeable. This caution, however, must go along with it, that in case of hard swellings, scirrhosities, or predominant acid, it will rather prove hurtful than of service.

## PROCESS CLII.

### *Exhibiting the Solution or Tincture of* IRON *in small distilled Vinegar.*

*The process.* 1. *IF instead of the* Rhenish *wine used in the preceding process, twelve parts of small distilled vinegar be poured upon one of the clean and bright filings of iron, and they be boiled together for some hours, there will be obtained a rich, blood-red tincture, highly impregnated with the sweet, styptic, nauseous taste of the metal.*

*Its nature.* 2. In neither of these two last processes is there a perfect dissolution made of the iron, at all like what is effected by oil of vitriol; tho the spirit of vinegar operates much more powerfully than the *Rhenish* wine upon it.

*Medicinal virtues of the production.* 3. The medicinal virtues of this tincture are nearly the same with those of the tincture made with *Rhenish* wine, but considerably stronger; so that twenty drops of this will answer to half an ounce of the other. It is an admirable remedy for the rickets, as also against viscid phlegm and worms in the bodies of children, operating without causing any disorder; provided they be first purged with scammony and mercury. It may be fitted for this purpose by being boiled up into a syrup with sugar, or mixed and given with any proper syrup, boiled to a high consistence. A few drops of this medicine taken every day in this manner, for some continuance, may prove very beneficial to young children; and recover them, when grown emaciated, pale, and feeble, to a florid colour and strength of limbs. The same medicine is also of excellent service in the disorders proceeding from a suppression of the menses; being taken in the quantity of a dram, once a day, upon an empty stomach.

## PROCESS CLIII.

### *Exhibiting the Sublimation, Volatilization, and Solution of* IRON, *with sal-ammoniac.*

*The process.* 1. *TAKE equal quantities of new and bright filings of iron and sal-ammoniac, and grind them together in a glass mortar for a considerable time, the longer the better, till they are reduced to fine powder; then put this powder into a coated retort, fit on a proper receiver, and sublime the mixture, with a due*

*due degree of heat in a ſand-furnace. The firſt thing that comes over will be a fiery alkaline ſpirit, ſharp, volatile, pungent, and almoſt ſuffocating, not unlike ſpirit of ſal-ammoniac prepared with quick-lime. After this, white fumes will riſe and concrete into flowers of ſal-ammoniac; and, upon conſiderably increaſing the fire, into glebes of various colours, containing a large portion of the body of the metal; whence they are called flowers of iron. And the operation being continued, with this degree of fire, till nothing farther will come over, there remains, at the bottom of the retort, part of the ſubſtance of the iron, ſo opened and abſolutely changed by the ſal-ammoniac, that when expoſed to the air it will ſwell, heave, grow ſpongy, almoſt fall into fermentation, and at length run* per deliquium *into a kind of oil.*

2. The ſtrong, volatile, alkaline ſpirit, ſeems, on this account to riſe firſt in the operation, that the acid of the ſea-ſalt in the ſal-ammoniac being converted to acid, is forcibly attracted by the iron, which appears to be a kind of magnet with reſpect to acids; ſo that the alkaline part is left at liberty to go up with the firſt degree of heat. And hence we have a general method of reducing all metals to flowers; for ſublimation with ſal-ammoniac has the greateſt power of volatilizing, opening, and diſſolving fixed metalline bodies. Whence this operation is called the chemical peſtle; as effecting a more perfect ſolution of metals than any other method. On the ſame account ſal-ammoniac is called the key or opener, and by ſome the white eagle, which bears away the parts of metals with its wings. This proceſs, likewiſe, ſhews us another way to obtain the oil of metals *per deliquium*, as alſo their tinctures; for the remainder of our preſent proceſs, will, by digeſtion, make an excellent metalline tincture with ſpirit of wine; and, as well as the flowers, run into a liquor in the open air. In like manner may the vitriols of metals, reduced to a calx, be more eaſily ſublimed into flowers. And theſe flowers being diſſolved in water, will thereby be ſeparated from the ſalt, and left in their utmoſt degree of purity and perfection; in which ſtate they are fit for the more curious purpoſes of chemiſtry or medicine. And according to *Paracelſus*, all metals are in a ſtate of death, till diſſolved by a corroding menſtruum, and afterwards revived and quickned by this kind of ſublimation.

*Its nature and uſes.*

3. The flowers of iron, obtained by this proceſs, are of a ſweetiſh, ſtyptic, nauſeous, oily taſte, but of a very ſtrengthening and aperitive virtue, when uſed internally; tho they are apt to prove emetic or nauſeous upon the ſtomach. They receive their virtues from the ſal-ammoniac, in conjunction with iron; whereby its body is ſo opened as to become of very great efficacy in the cure of the rickets, and capable of performing all, and perhaps more than Mr. *Boyle* has ſaid of the *Ens Veneris*. Taken in the quantity of a few grains, this medicine powerfully ſtimulates the firſt paſſages, and proves of very great ſervice in all diſtempers ariſing from flaccidity of the fibres.

*Medicinal virtues of the production.*

## PROCESS CLIV.

*Exhibiting the Calcination of* IRON, *or the preparation of* Crocus Martis aperiens, *with Sulphur.*

*The process.* 1. GRIND *together equal quantities of clean and bright filings of iron, and flowers of sulphur, into a fine, brown powder; put the mixture into a strong, earthen crucible, which being but lightly covered and placed in the fire, the sulphur in burning, will, by its acid, then set free, perfectly dissolve the iron, and leave it in the form of a calx or powder; called by the name of* Crocus Martis aperiens, *or* Chalybs cum Sulphure paratus.

*Varied.* 2. The same effect may be produced by grinding the iron filings and sulphur together, and afterwards reducing them to a paste with water; for this paste being suffered to lie for about an hour in an earthen vessel, will conceive a great degree of heat, which spontaneously ceasing, leaves the iron converted into a crocus. Which experiment may serve to explain the phænomena of earth-quakes, and subterraneous fires. For if such a mixture should, as it easily may, happen to be made in the bowels of the earth, it would grow hot, take fire, and violently tear up whatever opposes its expansion.

*Its use.* 3. This process, which exhibits the method of dry calcination, or Dr. *Willis*'s way of preparing iron for medicinal uses, gives us a general rule for calcining all kinds of metals, or reducing them to powder, by the assistance of sulphur. But the iron thus calcined seems to be destroyed; for it cannot, by the fire, be reduced to metal again. And as to the medicinal virtues of this preparation, I have always found crude iron more effectual.

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# CHEMICAL HISTORY *of* LEAD.

## PROCESS CLV.

*Exhibiting the Solution of* LEAD, *or its conversion into Ceruse by the fumes of vinegar.*

*The process.* 1. BEAT *pure lead into thin plates, and suspend them, by a proper contrivance, in the head of a glass alembic, wherein vinegar is to be distilled, or in any other place, so that they may be penetrated by the fumes of that liquor, which will thus corrode the metal, and turn its surface into a*

2 *white,*

*white, crusty matter, or ceruse, and afterwards drop down or distil into a sweetish, saccharine liquor, without any acidity. This white, crusty matter being beat or scraped off from the plates, they may be again exposed to the vapour of vinegar in the same manner, and afterwards scraped or brushed as before, till, by repeated operations, the body of the lead is thus wholly dissolved, or converted into ceruse, or the common white lead of the shops; which need only be dried, and reduced to a very white powder, to render it insipid, or fit it for use.*

2. This ceruse is nothing more than the calx of lead, made by the acid of the vinegar corroding the metal; and may as justly be called the rust of lead, as verdigrease is the rust of copper, or *crocus Martis* the rust of iron; all of them being the respective metals themselves corroded by an acid spirit, that is afterwards totally or in part exhaled. Whence we see how easy of solution the body of lead is, as yielding to a mild, vegetable acid; from which it also parts as easily. *Its nature.*

3. Ceruse is an useful medicine; being a great dryer and absorbent, when externally applied; but of a slow, poisonous nature, when admitted, in any quantity, into the body. It has wonderful virtues in drying up all running sores, or draining sanious ulcers; especially where the matter they discharge is acid or saline. On the same account it is serviceable in case of moist and inflamed eyes; especially being applied in a dry form thereto. But in all disorders proceeding from an alkaline cause, as the plague, certain kinds of fevers, &c. it is highly prejudicial; and indeed ought scarce at all to be given as an internal medicine, tho in ever so small a dose. The miserable people who for gain daily assist in the preparation of this commodity, run a great hazard of their lives, and seldom hold out for more than four years: they usually, before that time, become phthisical, and dye of an incurable consumption. And this might give occasion to the notion, that *Saturn*, the chemical name for lead, destroyed his children; as it does, the baser metals upon the test. What some time since happened in *Germany*, gives a sad proof of the poisonous quality of this metal: the avarice of some vintners having induced them to take off the too great acidity of their *Rhenish* wine by means of white lead, which it does to great perfection, those that afterwards drank of that wine, who were to the number of above a thousand men, fell into a miserable tabes, and died; which occasioned this practice, for the future, to be made a capital crime. This preparation is likewise very pernicious, when long used as a fucus for the face. Indeed it gives a beautiful white for some time; but afterwards brings on an odious paleness, quite destroys the natural colour, and sometimes, by long use, brings on asthmatical or phthisical disorders, and proves actually mortal. *Nature and uses of the production.*

## PROCESS CLVI.

### *Exhibiting the Calcination of* LEAD*; or its reduction to* Minium, *or* red-Lead.

*The process.* 1. MELT *a quantity of lead in a wide iron or unglazed earthen vessel, and at first the face of the metal will appear perfectly smooth and polite, but will afterwards grow dull, opake, and contract a pellicle or crust; which being taken off with an iron ladle, a new pellicle will be generated, and cover the surface of the metal; and this being taken off as before, new pellicles will arise; and thus, by continuing the operation, the whole body of the lead may be converted into the like calx. If now this calx be put into a larger vessel, exposed to a violent fire, and there kept continually stirring with an iron rod, it will gradually change its colour to grey, brown, and yellow; and at length, by the farther action of the fire, wherein it is to be detained for several hours, appear in the form of a vivid red calx, or powder, called by the name of minium, red-lead, or cinnabar of lead, and, improperly, litharge.*

*Its effects.* 2. It is very remarkable in this operation, that the metal continually gains in weight as it changes its colour, so that when turned to minium, it acquires no less than a twentieth part; that is, if nineteen ounces of lead were to be treated in this manner, the red-lead would weigh twenty. This great increase of weight has generally been thought owing to the fire, fixed by the operation in the body of the lead. And Sir *Isaac Newton* conceives, that the red colour of the minium is owing to the fire thus concentrated or lodged in the metal. But I cannot subscribe to this opinion, without distinguishing between fire and fewel. I have already proved, and experimentally shewn, in my public lectures, that fire is destitute of weight; and consequently this increase of gravity in the lead cannot be owing to fire, strictly and properly so called; but perhaps it may to the parts of the fewel employed in the operation. This increase of gravity is the more remarkable, because the metal always affords a considerable fume in the operation; whence one would expect it should lose of its weight.

*Nature of the production.* 3. Red-lead differs from litharge, in that the former is made *per se*, as in the present experiment, without mixing with other metals; whereas litharge is a frothy matter, that adheres to the sides of the test, floats on the surface of lead when fused or cupelled with the nobler metals, and is therefore a more imperfect or undigested minium, mixed with the drossy matter of silver or gold, and of a paler colour than red-lead; and accordingly it is called litharge of gold or silver, as it is obtained or thrown off in purifying those metals. Either kind is, however, capable, by violent ignition, of being brought into the form of minium.

4. It was minium, thus prepared, wherewith the *Roman* and *Grecian* ladies tinged their nails and faces of a red colour; as we learn from *Plautus* and other antient authors. But being of a pernicious nature, it ought to be used with prudence. Externally applied, it has much the same virtues with ceruse. It perfectly dissolves in linseed oil, or oil-olive, by coction; and thus makes *deminium*, which is an excellent plaister for chirurgeons, and one of the best remedies in use for the gout; especially if it be made with wax alone instead of oil, or other unctuous bodies. *Its uses and virtues.*

## PROCESS CLVII.

### *Exhibiting the* Solution *of* LEAD *in distilled vinegar, or the preparation of the metalline* Lac Virginale.

1. *UPON a proper quantity of crude lead, lead-ore, minium, ceruse, litharge, calx, or spume of lead, put into a tall glass, pour twenty times its own quantity of spirit of vinegar, and let them boil together for four and twenty hours, the vessel being shook between whiles; then, whilst the liquor is hot, filtre it thro' paper, or suffer it to settle, and pour off the clear by inclination, and it will be a solution, of a nauseous, saccharine sweetness, without any acidity, called in the shops vinegar of litharge, but by the chemists metalline* Lac Virginale. *And if fresh spirit of vinegar be poured to the fæces, and the operation be repeated, the whole body of the lead may, by degrees, be dissolved into the like liquor.* *The process.*

2. If the solution be filtred, it ought to be filtred hot, because it will scarce pass the pores of the paper when cold. It is called vinegar of litharge in the shops, only because they usually prepare it with litharge instead of lead. *With what caution to be performed.*

3. This process furnishes us with another method of reducing metals to oil; for if the clarified solution it affords be evaporated to the consistence of honey, fresh spirit of vinegar be poured thereon, the matter be again inspissed, and the operation repeated as before for a number of times, there will be obtained the ponderous oil of lead, which is exceeding difficult to dry at the fire. And this shews us, that metals are reducible to oil, by intimately impregnating their substance with acid: which also appears to be the case when they are run to oil *per deliquium*. *Its uses.*

4. This solution of lead is greatly commended, as an external, in case of stubborn inflammations, and old, inveterate ulcers; and chirurgeons frequently use it in phlegmons, and erysipelatous cases. Being infused with an equal quantity of oil of roses, it makes a noble white balsam for these purposes, called by the name of *Unguentum Nutritum*; but it is actually poisonous when given internally. It gives a beautiful whiteness to the skin; but is a very noxious fucus, as causing violent disor- *Virtues and uses of the production.*

 ders

ders in the lungs, phthisical and asthmatical complaints, or throwing the person who uses it into a pulmonic consumption. I have my self known some young ladies who killed themselves by frequently employing it as a wash. In like manner, three sisters at the *Hague* died miserably tabid, by endeavouring with it to change the colour of their hair from red to black. And indeed those who deal much with lead, in what form soever, are seldom long-lived.

## PROCESS CLVIII.

### *Exhibiting the Solution of* LEAD *in distilled vinegar, or the method of obtaining its Vitriol or Sugar.*

*The process.*

1. *EVaporate the solution, or metalline* Lac Virginale, *of the preceding process, to the consistence of honey, and again let it down with fresh and strong spirit of vinegar; afterwards exhale it away again to a pellicle, or almost to dryness; then set it in a cool place, and it will concrete into a soft, white mass, or salt, of a saccharine taste: on which account 'tis called sugar of lead, as it is also the vitriol or magistery thereof.* (2.) *If this vitriol, or sugar of lead, be again perfectly dissolved in spirit of vinegar, and afterwards inspissated to the consistence of oil, or till a pellicle appears on its surface, and be set again to shoot in the cold, it will form it self into small and flat quadrangular glebes, or beautiful crystals, not unlike to sugar-candy.* (3.) *Repeat this operation several times successively, and at length you will have an oil of lead, that can neither readily run into crystals, nor dry at the fire.* (4.) *Again, if this oil of lead, thus frequently impregnated afresh, be, by a long continued and gentle heat, brought to dryness, it will thereby be turned into a spongy mass; which, in many of its natural properties or characters, resembles silver.* (5.) *Lastly, dissolve this mass again in spirit of vinegar, and evaporate it to the thickness of oil; after which, being set to shoot, it will afford the most beautiful crystals that can by any means be obtained from lead.*

*Observations thereon.*

2. It is observable, that by the evaporation of the solution in this process, 'tis only an aqueous, not an acid vapour that flies off; which being caught and condensed, turns to an almost insipid water, but something nauseous. And accordingly, if the vitriol, when perfectly formed, be dissolved in water, it will again afford the *Lac virginale*. The oil obtained in the present process, is called the incerated oil of lead; because it flows or remains fluid like wax at the fire. And after the same manner may several other metals be reduced to a like kind of oil.

4. *If. Hollandus* imagined, that the philosophers stone, and afterwards silver, was obtainable from lead treated in the manner of this process. Indeed the oil here procured, being poured out of one vessel into another, does seem to run in silver threads. But the operation is excessively tedious; for the solution must be several times repeated, and the exhalation very gradually made, before the experiment will succeed. Ano-

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ther author has mentioned ſome curious particulars of this liquor, in the philoſophical tranſactions of *London*, but conceals his proceſs.

4. The medicinal virtues of *Saccharum Saturni*, or the vitriol of lead, are theſe: it is a very powerful ſtyptic, preſently coagulating the blood, and conſtringing the mouths of the bleeding veſſels. It is good againſt inflammations; being diſſolved in water, and uſed by way of a fomentation. And in many other reſpects it will anſwer the intentions of the phyſician or chirurgeon, uſed as an external: but I cannot imagine it ſafe to give it, as ſome do, internally. Almoſt all the modern phyſiſicians, I know, ſcruple not to adminiſter it in intermitting fevers, and other diſtempers; but with what ſucceſs they beſt can tell. With me it ſtands in the catalogue of poiſons. And tho it may cure the fever, it is apt to leave a worſe diſorder behind it. This is certain, if it meets with an alkali in the body, it will thereby be turned to a calx, or ceruſe, which all acknowledge to be poiſonous; being only kept in a ſaline form by means of the acid of the vinegar. And accordingly, I have obſerved ſeveral perſons to complain of a weight at their ſtomach, loſs of appetite, impotency, and ſeveral other diſorders from the internal uſe thereof: and indeed it has at length thrown them into a lingering conſumption. The *Italians* are well acquainted with theſe effects of this preparation; and employ it when they deſire to be ſlowly revenged of their enemy. A famous *Italian* phyſician once told me, that no medicine was uſed by the monks with ſuch great ſucceſs as this, for extinguiſhing all deſires to venery, which kind of appetite it infallibly deſtroys.

*Medicinal virtues of the production.*

## PROCESS CLIX.

### *Exhibiting the Solution of* LEAD, *or the method of procuring its Vitriol with ſmall* Aqua fortis.

*The proceſs.*

1. TO *a proper quantity of crude lead, ceruſe, minium, or litharge, put into a tall glaſs, pour an equal, or double weight of ſpirit of nitre, or* Aqua fortis, *which being diluted with ten or twelve times its own quantity of fair water, will preſently diſſolve the lead with an audible noiſe. Then directly filtre the ſolution, and it will become a perfectly tranſparent liquor, of a nauſeous, ſaccharine ſweetneſs, containing the whole body of the metal. And this ſolution being evaporated, and treated in the manner of the preceding proceſs, will exhibit the ſame phænomena, and afford another vitriol of* Lead.

*Its effects.*

2. The productions of this proceſs are much the ſame with thoſe of the foregoing; the oil and the vitriol obtained by it having the like virtues, but ſtronger than the former. The cryſtals, however, of the preſent proceſs, are of an elegant and ſingular ſtructure, different from all other kinds of vitriol; being, if the exhalation was gentle and gradual, ponderous, white, ſweet, beautiful, inflammable like nitre, and crack-

ling in the fire more than any other known ſalt. With a ſtrong heat they will fume, part with their acid, and be reduced to a calx. By this proceſs, alſo, the ſugar of lead is obtainable with greater expedition, and to more advantage than with vinegar. And hence we may learn, that lead is eaſily diſſolvable in any kind of acid; and that it conſtantly acquires a ſaccharine ſweetneſs thereby. But then the acid muſt not be too ſtrong, or have its ſalts wedged too cloſe together; for ſtrong ſpirit of nitre will ſcarce act at all upon this metal, till the ſalt thereof is diſſolved, or ſet free by the admixture of water. It is likewiſe very obſervable, how attractive all metals are of acid, or how readily their texture is diſſolved, and their taſtes varied thereby. Thus the ſolutions of inſipid lead and iron, we have found taſte differently nauſeous, ſweet, auſtere, or vitriolic, whilſt that of ſilver is exceedingly bitter.

## PROCESS CLX.

### *Exhibiting the preparation of the Balſam of* LEAD, *with Oil of turpentine.*

*The proceſs.* 1. U*PON any quantity of the dry vitriol, or calx of lead, put into a tall glaſs, pour about four or five times its weight, more or leſs, according as the balſam is deſired thick, or liquid, of oil of turpentine; and boil them together, for ſome hours, till the whole body of the metal is perfectly diſſolved into a thickiſh ſubſtance, which is the genuine or metalline balſam of lead.*

*Its uſe.* 2. The effect will be the ſame, if ſugar of lead, ceruſe, or minium, be boiled to a due conſiſtence, either in oil of turpentine, oil-olive, or any diſtilled eſſential oil. Whence it is evident, that metals are diſſolvable, or reducible to balſams with oils; in agreement with the doctrine of the chemiſts, but contrary to the opinion of the vulgar; tho the thing was known to the antient *Greeks* and *Egyptians*, and is daily practiſed in the boiling of plaiſters and unguents.

*Virtues of the production.* 3. This balſam is much commended againſt external inflammations, ſcirrhous tumors, and venereal ulcers, buboes, *&c.* *Baſil Valentine* is extravagant in its praiſes; but I could never find that it had any extraordinary or ſpecific virtues, more than the common balſam of ſulphur.

## PROCESS CLXI.

### *Exhibiting the converſion of* LEAD *into Glaſs, or the preparation of* Vitrum Saturni, *with ſand.*

*The proceſs.* 1. T*O one part of ceruſe, minium, or litharge, add two or three parts of the powder of clean, white ſand, or calcined flints, and grind them well together in a mortar; put the mixture into a ſtrong crucible; detain it in*

*a*

*a fire of fusion for half an hour, and the matter, towards the top of the crucible, will, when cold, appear in the form of a transparent, brittle, or vitreous body, called the glass of lead; the metal, if any remain unreduced, subsiding to the bottom.*

2. To make the flux the stronger, a due proportion of dry nitre may be added to the mixture, either before or after it is melted. Or the process may otherwise be performed, by taking four parts of minium, and one part of calcined flints or sand, and fluxing them with two parts of sea-salt, in a very violent fire. After which, the crucible being suffered to cool, upon breaking of it the upper part of the matter will be found vitrified; what is metalline remaining at the bottom. And this shews us the general method of reducing all metalline bodies to glass; which is done by first bringing them to a calx, and then fusing them in a close crucible with sand. *How to be varied; with its uses.*

3. This glass of lead, otherwise called metalline amber, being fused in a test, will readily flux any other body that is put to it; upon which the whole art of refining or assaying entirely depends: for if any metalline glebe, or ore, tho ever so much mixed with stones, sand, or other heterogeneous bodies, be but fluxed, or cupelled with this glass, it drinks in all the metal they contain, and throws to the surface whatever is of a different nature. And if the fire be violent, and long continued, the glass it self will run, like water, thro' the pores of the cupel; leaving nothing but pure and perfect gold or silver behind it. Whence lead is not improperly called by the chemists the bath, devourer, or purger of metals. Thus in order to purify silver, or separate it from its ore, we need only fuse or cupel it with about four times its weight of glass of lead, till, by blowing with bellows upon the face of the metal, all the impurities are driven off, and the surface of it is left pure and shining, and the glass of lead is run thro' the pores of the cupel. And if any vessel could be found capable of containing this glass in fusion, we should then have an admirable method for making silver. *Uses of the production.*

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# Chemical History *of* SILVER.

## PROCESS CLXII.

### *Exhibiting the Solution and Crystallization of* SILVER, *in* Aqua fortis.

1. PUT *any quantity of perfectly pure silver, cupelled with lead or* vitrum Saturni, *into a clean glass; pour upon it about an equal or double weight of proof spirit of nitre, or* Aqua fortis, *and the liquor will presently conceive a degree* *The process.*

*degree of heat, emit a copious red fume, which is carefully to be avoided, and at length the body of the metal will be perfectly dissolved into a pale, homogeneous, transparent liquor, like water in appearance. But if the solution does not proceed to expectation, more spirit of nitre may be added, by degrees.* (2.) *When the solution is thorowly effected, let one half of the liquor be evaporated over a gentle fire, in a chimney, to carry up the fumes; after which, if set in a cool place, it will shoot into glebes, thin plates, or crystals, of an exceeding bitter taste, which are called the vitriol, salt, magistery, or crystals of silver.*

*The cautions it requires.* 2. Unless the silver be made perfectly pure and fine, that is, unless it has been fulminated or cupelled, as the chemists call it, with lead, and freed from all dross or allay, so as not to lose of its weight in the strongest fire, the solution will not be limpid; and if ever so little copper remain in the silver, it will turn the solution of a greenish colour. The spirit of nitre, likewise, should be proof; that is, if a grain or two of silver be added to a moderate portion thereof, it should perfectly dissolve it without growing turbid, or letting any white powder fall to the bottom. And if the dissolution proceeds too slowly, it may be quickened, by placing the containing vessel in a moderate heat. If any gold happens to be mixed with the silver, as there is scarce any without, this not going from it upon the test, it will fall to the bottom of the glass, in the form of a black powder or pellicle, and there lie undissolved; *Aqua fortis* not touching gold, which is only dissolvable by mercury and *Aqua regia.* And this black powder will sometimes adhere to the under surface of the crystallized silver.

*Nature and uses of the productions.* 3. This solution of silver is violently corrosive or caustic, so as presently to eat into any part of the body. On which account, 'tis very useful to chirurgeons, in opening impostumes, or the like; and admirably serves to take away warts or other excrescences, which it does with the utmost dispatch. It is likewise used to mucous fistula's, and putrid, gleeting ulcers, in order to deterge them, and keep down fungous flesh. A few drops of it being mixed with a pint of water, will communicate such a faculty thereto, that if the face, hands, or other parts of the body be washed with it, they instantly turn black; and this stain remain so obstinate, that it cannot, without the utmost difficulty, be entirely got out again in less than three or four days time; when, the part scaling, it comes away together with the skin. And as the solution readily mixes with water, we see that even the hardest and purest metals may be rendered fluid, potable, invisible, or undistinguishable. I would not, however, advise, that silver should be exhibited internally in this form; because of the corrosiveness of the acid wherewith it is united, which might cause it to excoriate the parts it should touch or pass over.

4. The vitriol, or crystals of silver obtained by this process, are found to increase their weight by near one third or fourth part, above that of the original metal; which must, therefore, attract, and lodge in its pores, some part of the spirit of nitre, by means whereof the silver

silver is made to assume the form of a salt, and become soluble in water. But its violently bitter taste, on account whereof 'tis called metalline gall, together with its caustic quality, renders it unfit for internal use, unless it be some way guarded, disguised, or corrected. And even when used externally, it cannot be held in the naked fingers without corroding the flesh.

## PROCESS CLXIII.

### *Exhibiting the preparation of the Lunar caustic, or* Lapis Infernalis, *from the Vitriol of* SILVER.

1. PUT *a proper quantity of the vitriol, or crystals of well purified silver into a thin glass dish, which being set over an open fire, the vitriol will begin to afford red fumes, and grow gradually dry. As soon as all its moisture is nearly evaporated, increase the fire, and cause it to flow like wax, till no more fumes ascend: then pour it into moulds of baked clay, and furnished with a sufficient number of conical or cylindrical cavities, into which it will run with a hissing noise, and thereby be fashioned into convenient rolls, or sticks; which, when cold, may, by breaking the mould, be obtained, and reserved for chirurgical uses, under the name of* Lapis infernalis, *or the silver caustic* *. *The process.*

2. If this caustic be prepared after the manner here described, it will be capable of enduring the open air without relenting; whereas that made in the common way of the trading chemists, can scarce in a lose glass be kept, for any considerable time, from melting. The reason whereof is, that either they do not make use of silver well purified from its alloy, or else because in fusing their crystals, they have not patience to wait till the fumes entirely cease; that is, till a proper quantity of the acid of the nitre be exhaled. For if any copper, or too large a proportion of *Aqua fortis*, be mixed along with the stone, it will certainly run *per deliquium* in the air. The goodness of the preparation greatly depends upon nicely hitting the time when the fumes entirely cease to rise; for if the matter be after this continued much longer in fusion, its caustic virtue will be lost; and if removed from the fire before this juncture, it will, as we said, be apt to run in the air. The glass to be made use of in the operation is ordered thin, because such an one will better endure the necessary violence of an open fire, than one that is stronger or thicker: a piece of a broken urinal, or the like, will, therefore, be proper for the purpose. *With what caution to be performed.*

3. *Lapis infernalis* then, we see, is no more than the strong and corrosive spirit of nitre intimately united with the body of silver, or no- *Medicinal uses of the production.*

* The moulds ought first to be warmed, and oiled or greased, that the caustic may be separated from them the easier.

thing but the dried salt thereof; for if it be entirely freed from the remaining part of the *Aqua fortis*, it will become pure silver again. Thus composed, it makes an admirable caustic; for it eats like fire it self, when dissolved by any moisture of the body, and suddenly cleanses and deterges all foul or malignant ulcers, cauterizes the open vessels therein, disposes them to heal, and, with the lightest touch, takes down warts, fungous flesh, small cancers, and the like præternatural tumors or excrescences, provided they are not large. I have, without pain, in the space of three days, taken away a little cancer in the lip by its means: for being several times touched therewith, it turned black, and at length fell off from the surrounding flesh. When applied to any part of the body, it immediately eats into it, burns it, mortifies and renders it insensible; at the same time causing an eschar, and constringing and pursing up the mouths of the vessels it corrodes. And being so excellent in these respects, it is the only caustic in use among the *French*.

## PROCESS CLXIV.

### *Shewing the way of making purging Vitriol of* SILVER, *or the preparation of the Silver Pill.*

*The process.* 1. TO *the solution of pure silver, made after the manner of the hundred and sixty second process, and put into a glass vessel, add an equal quantity of a strong lixivium of purified nitre, made with about two or three parts rain-water; shake them together, and they will unite into a transparent liquor; which being evaporated to half its original quantity, and set to shoot in the cold, will run into a vitriol, or crystals, consisting of silver united with saltpetre.* (2.) *Put these crystals into a glass dish, and exhale away their moisture over a soft fire; keeping them in the mean time, perpetually stirring, and preventing their fusion.* (3.) *Remove them from the fire, and when they cease to fume, they will appear in the form of a black, saline body, a grain or two whereof being brought into powder, and with thrice that quantity of new bread reduced to a pill, and gilt with gold, to guard it from the palate, makes a pleasant and powerful hydrogogue, or purger of water in the dropsy.*

*Virtues and uses of the production.* 2. This process shews us a general method of joining metals with salts, so as to make them appear altogether in a saline form. *Angelus Sala*, the author of the production, calls it by the name of *Luna hydrogoga*, as being peculiarly excellent in purging away the watery humors collected in the dropsy; for which purpose, it is likewise greatly commended by the illustrious *Boyle*. And indeed it proves, when prudently used, an admirable purgative in this case; and drains off the waters without causing any disturbance to the body. But great care must be taken not to give it in weak habits of body, in too large a dose, or where the viscera are unsound. For differing not considerably from the lunar caustic, it might thus violently stimulate, corrode, or inflame the stomach and intestines, bring on a dangerous hypercatharsis, or sollicit a copious,

copious, continual, and insensible discharge from the lymphatics. If any thing of this kiud should happen in the use hereof, it will be proper to attempt its cure by the free exhibition of the rob of juniper or elder.

## PROCESS CLXV.

### *Exhibiting the Precipitation of* SILVER, *and its reduction to* Luna cornea.

1. *TO a solution of pure silver, made with spirit of nitre, and diluted with about thrice its quantity of fair water, pour a strong lixivium of sea-salt; upon which, the liquor that was perfectly clear before, will immediately grow turbid, and let fall the body of the silver in a white powder, to the bottom of the containing glass. Commit this powder, together with the liquor that floats above it, to the filtre; and by frequent ablution, or repeated affusions of warm water upon the matter in the filtre, edulcorate or clear it of its loose salt; then gently dry the powder, and thus it will be reduced to a genuine calx of silver. Lastly, put this dry calx into a crucible, and fuse it at a moderate fire; and after it has run for some small time, pour out the matter, and when cold it will appear in the form of a horney, brittle substance, not much unlike amber, or glass of lead; and, for the resemblance it bears to horn, 'tis called by the name of* Luna cornea. *The process.*

2. There is another way of making *Luna cornea*, by mixing silver with mercury sublimate, and distilling the composition in a retort, after the manner of butter of antimony, the process for which we shall deliver hereafter; when, the mercury being driven over into the receiver, the salts of the sublimate will remain behind, fixed in the body of the silver, and therewith compose the same kind of horny, or glassy substance, as mentioned in the process. *Varied.*

3. This process affords us several very remarkable particulars. And first we may observe from it, that silver is undissolvable in *Aqua regia*; being, as we see, precipitated out of *Aqua fortis*, made into a small *Aqua regia*, by the addition of the lixivium of sea-salt. Secondly, tho the *Luna cornea* be long exposed to ever so violent a fire, it will not, without some addition, be thereby reduced to metal again; tho, beyond all dispute, it is actually the body of silver fixed but by salts. And accordingly, if lead, or fixed alkali, be added in a proper proportion thereto, so as to attract or imbibe the acid salt, which thus obstinately adheres to the metal, and its face be strongly blown upon with bellows, whilst it is in strong fusion, the silver will be recovered pure; and if, after this, it be again dissolved in *Aqua fortis*, it affords a considerable proportion of gold. Thirdly, it is farther observable, that this strange substance, reduced to powder, tho it readily melts at the fire, will neither dissolve in *Aqua fortis*, *Aqua regia*, nor oil of vitriol; so that it entirely acquires a new nature. On these accounts, many of *The doctrine it affords.*

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the antient chemiſts called it *Luna fixa*; and imagined the body of the ſilver was here ſo changed as to be readily convertible into gold: and indeed, the experiment does not ſeem to want much to bring it to that perfection. Laſtly, we may here ſee the great effects which ſalts have upon metals; how they may contribute to their fixation; and, by intimately and ſtrongly uniting therewith, conceal their own nature, and endure the utmoſt torture of the fire without flying off; tho of themſelves they are little other than volatile.

## PROCESS CLXVI.

### *Exhibiting the Reduction of* SILVER *to metal again, from its inflammable Vitriol or Nitre.*

*The proceſs.* 1. PUT Lapis infernalis, *or the cryſtals or vitriol of ſilver, obtained by diſſolving the metal in ſpirit of nitre, upon a hollow, glowing coal, and it will immediately flaſh, deflagrate, and go off like true ſalt-petre; leaving nothing behind but the pure ſilver, thus recovered from its cryſtals.*

*The doctrine it affords.* 2. We formerly ſaw that the ſpirit of nitre, joined with fixed alkali, gives inflammable nitre again; and here we ſee, that the body of a metal may likewiſe perform the ſame office. It alſo appears from this proceſs, that nitre, tho made liquid, or reduced into the form of a ſpirit, ſtill retains its ſaline and inflammable nature; and that *Lapis infernalis*, or vitriol of ſilver, is nothing more than this volatile ſpirit of nitre, adhering intimately to the body of the metal; and which, when driven away by the fire, leaves the ſilver behind, as it would any other metal diſſolved thereby, in a pure, ſimple, and unactive ſtate: which gives us the reaſon why, if *Lapis infernalis* be too long detained in fuſion at the fire, it will thereby loſe of its force, or cauſtic virtue, by loſing of its ſalt. And this may ſerve to ſhew us, that the actions of all metals are not owing to themſelves; they being perpetually unactive; but to the ſaline bodies with which they happen to be mixed; and according to the nature whereof their action is determined. But in this caſe, the power and virtues of the ſalts are neceſſarily increaſed, as being now applied, and driven by the ponderous, metalline part, united with them, againſt the bodies they are deſigned to act upon. And this will help us to conceive ſomething of the ſurprizing nature of metals, when formed into new bodies with ſalts.

CHE-

# Chemical History *of* TIN.

## PROCESS CLXVIII.

### *Exhibiting the Calcination, Solution, and Crystallization of* TIN.

1. *PUT any quantity of pure * tin into an iron or unglazed earthen pan, and melt it in a strong fire; keeping the matter continually stirring, till it be reduced to a dry powder, or calx.* (2.) *Then put of this calx of tin into a glass vessel, and pour thereon about ten times its quantity of distilled vinegar, and let them digest together in a proper degree of heat; the glass being frequently shook, for two or three days, or till the menstruum has acquired a sweet taste; or till the solution is effected.* (3.) *Lastly, filtre the liquor, evaporate it to a film, or pellicle, and set it in a cool place to shoot; by which means it will form into crystals.* *The process.*

2. The body of tin is not so readily convertible to salt, or vitriol, as silver; on account of the gross sulphur adhering thereto, which can never be dissolved by acids, but interposing between the metallic parts, prevents its concretion. But if the calx be thorowly purify'd, reverberated, or long continued in a violent fire, it will in good measure be freed of its sulphur, and more disposed to shoot into crystals. † *Directions relating to it.*

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# Chemical History *of* COPPER.

## PROCESS CLXVII.

### *Exhibiting the Solution and Crystallization of* COPPER, *by means of distill'd* Vinegar.

1. *UPON the filings of pure copper, put into a glass vessel, pour a proportionable quantity of distill'd vinegar, and boil together for four and twenty hours; by this means there will be obtain'd an exceeding beautiful green* *The process.*

* The common method of purifying tin for chemical operations, is to melt it in a clean iron pan, and just as it begins to run, adding thereto a suitable proportion of wax, honey, or hogs lard; keeping the matter frequently stirring with an iron rod, and after some time throwing it into hot water. If this operation be several times repeated, the metal will, in some degree, be purged of its sulphur, and render'd more bright and hard.

† There are other processes commonly performed upon tin, tho not deserving to be mentioned here, as being no part of the present design; which is only to give such a set of general, standard operations, as may instruct the reader to manage all the others that have hitherto been invented.

*tinc-*

*tincture; which being poured off from what remains undissolved at the bottom of the glass, and fresh vinegar put on, and boiled as before, the whole body of the metal will, by repeated operations, be dissolved into the like green tincture. (2.) If this tincture be evaporated to a pellicle, and set in a quiet cool place, it will shoot into lovely green crystals; which are used as a pigment, and commonly go by the name of verdigrease.*

*Varied.* 2. This vitriol of copper, or verdigrease, may likewise be obtain'd by exposing clean plates of the metal in any place where they are affected by the vapors of vinegar, or fermenting liquors; which gradually corrode and turn the surface thereof into a kind of rust, or *ærugo,* that by the microscope appears a heap of green crystals, like those of the present process. Then the loose matter being scraped off the plates with a knife, and they again exposed to the corroding vapour, they will thus by degrees, be totally converted into the common verdigrease of the shops.

*Nature of the production.* 3. This green vitriol of copper would be an admirable pigment, if its colour could but be render'd as durable as it is beautiful. Whoever could do this, might think himself possessed of a very beneficial secret. The reason why it loses of its beauty in the air, is the volatility of the acid wherewith the metal is joined; which being exhalable by the air, it leaves the metalline part of a grey, dusky colour.

*Its medicinal virtues and uses.* 4. This tincture and vitriol of copper are possessed of the same medicinal virtues; a very few drops of the former, or a single grain or less of the other, make an excellent emetic, where the occasion for one is very pressing and sudden; as particularly in case of poison receiv'd into the stomach. For as soon as taken, this medicine operates powerfully by vomit; but leaves a very disagreeable or nauseous styptic taste upon the tongue, for many hours after. It likewise destroys all kind of worms in the body, serves to dry up old gleeting ulcers, takes down fungous flesh, *&c.* and indeed it acts after the manner of *lapis infernalis,* but much more gently.

## PROCESS CLXI.

### *Exhibiting the Solution and Crystallization of* COPPER, *with the alkaline spirit of* Sal-Ammoniac.

*The process.* 1. U*PON clean filings of well purified copper, put into a tall glass, pour twenty times their quantity of the alkaline spirit of sal-ammoniac, prepared with quick-lime, and proceed as in the foregoing process; by which means the copper will be dissolved into a fine blue liquor, which being exhaled till a film appears on the surface, will in the cold form it self into crystals, or vitriol of the same colour.*

*Nature of the production.* 2. This vitriol, likewise, is an excellent pigment, but presently loses all its beauty; the volatile alkali wherewith the copper was dissolved, easily flying off from it in the air: otherwise it would be more

precious

precious, as it is of a much more elegant colour, than ultramarine; which being sold so dear, it would be a valuable thing cou'd we make the colour of this vitriol durable.

3. The tincture obtain'd by this process is not so vomitive as that of the preceding; and being given in the quantity of a few drops, operates powerfully by sweat and urine; whence it becomes curative of many diseases, and particularly the dropsy. And in this case I have found it effectual to a surprizing degree, even in old-age, when the collected water by long stagnating was almost putrefied in the body: by giving thirty drops of the solution, three or four times a day, with a little hydromel or syrup of juniper, there has follow'd such a copious discharge of urine, that in a short time all the stagnant waters have been entirely brought off that way. But when the dropsy is attended with a schirrhous liver, unsound viscera, or the like, I could never observe any good effect from this, otherwise, excellent medicine. It is likewise serviceable in killing worms, bringing away phlegm, and curing faintness, the rickets, and epilepsy, if, as frequently happens, in children, it proceeds from worms in the body, or viscid phlegm in the stomach. In general, it is of an attenuating, aperitive, stimulating, warming, drying virtue; and may in ordinary cases be given from twelve to four and twenty drops, three or four times a day, along with any vehicle that is not acid, which might render it emetic. Thus managed, and given in smaller doses to children, 'tis likewise wonderfully effectual in the cure of those distempers to which they are peculiarly subject. *Medicinal virtues of the production.*

4. We learn from this process, and the preceding, that copper is dissolvable in alkaline as well as in acid spirits. We may add, that it will likewise dissolve in neutral spirits, in *aqua regia*, *aqua fortis*, in *sal volatile oleosum*; and, in short, in all manner of saline menstruums. On which account it is generally called a public prostitute, by the chemists, and denoted by the name of *Venus*. With *sal volatile oleosum*, it makes a tincture of nearly the same virtues as that of the present process, but much more beautiful; and it is this tincture which I frequently use in my practice, and prescribe from eight to thirty drops, as a diuretic, or sudorific, in case of the dropsy, or other distempers; and universally, with acids, or those the chemists call masculine salts, it makes a green, but with alkalies, or the female salts, a blue solution; the latter kind being always less caustic and emetic than the other. *The doctrine of the process.*

CHE-

# CHEMICAL HISTORY *of* MERCURY, *or* QUICK-SILVER.

## PROCESS CLXX.

### *Exhibiting the Solution and Crystallization of* QUICK-SILVER, *in* Aqua fortis.

*The process.*

1. T*O a proper quantity of pure quick-silver,* **strained thro leather, and well ground in a mortar with sea-salt and vinegar, till it has deposited all its blackness, pour a double or a triple proportion of* aqua fortis, *the containing glass being first heated to prevent its cracking, and the mercury will immediately begin to dissolve, with a strong ebullition, and copious red fumes, which are to be avoided as noxious; and by degrees the whole body of it will be taken up, and with the menstruum appear as one homogeneous and transparent liquor. If the dissolution proceeds not to expectation, or it be incomplete, more* aqua fortis *should be poured on, and the operation thereof promoted by moderate heat.* (2.) *If this solution be exhaled, over a soft fire, to one half or less, and then set in a cool place, it will shoot into white glebes, or crystals, called the salt vitriol, or magistery of mercury; being in reality the body thereof, so united with the acid that it is violently caustic, and can scarce be kept from running* per deliquium *in the air.*

*Its use, with the nature of the subject.*

2. This process may serve to shew that mercury is of a metalline nature; being, like other metals, strongly attractive of the acid of nitre, and totally dissolvable therein, so as to lodge invisible, and thence become miscible with water, like all true metalline solutions; and by this means the mercurial part of all, even the most ponderous metalline bodies, may be suspended in water; *viz.* by being first united with an acid salt, which is always strongly attractive of water. The properties, and so much as regards the natural history

* The mercury found near gold-mines is supposed the best, richest, and fittest for chemical uses; as being impregnated with a golden sulphur. In the earth it is often mixed with arsenical, and other heterogeneous matters, which tho imperceptible to the senses, may render it noxious to the body, without due purification. The clean, wholesom mercury, 'tis said, may be distinguished from the foul, or adulterate kind, by the fine white lustre, and polite or glossy surface of the former; and by evaporating it over a naked fire in a silver vessel; for if it leaves no considerable tarnish behind, 'tis commonly thought to be pure. But it appears unsafe to depend upon any mercury for medicinal uses that is not revived from cinnabar, or fixed alkalies, or particularly from a double weight of the mixture of equal parts of quick-lime, and salt of tartar: the grinding and washing it with salt and vinegar, being by some thought only to dissolve the body of the mercury, it self black, and not to free it from arsenical or other noxious particles.

of this metallic fluid, we have formerly mentioned in the *Theory*, or *Apparatus*; to which we therefore refer for thoſe particulars. We ſhall only add here, that its chemical and medicinal virtues ſeem owing to its great ſpecific gravity, and the particular ſmallneſs and configuration of its parts. On this account it is more penetrative, and diſſolves the texture of the blood and juices, or opens obſtructions in the body more powerfully than any other medicine. And for the ſame reaſon it is, that it ſo ſuddenly brings a degree of putrefaction upon the humours, as we find in a ſalivation; for by thus breaking the texture of the fluids, and ſometimes of the ſolids likewiſe, it ſo attenuates and reſolves them as to make them fetid. For whatſoever reſolves the animal fluids, will neceſſarily give them a diſagreeable odour; and therefore the ill-ſcent obſervable in a ſalivation, is neither chargeable upon the infection of the diſeaſe, nor upon the mercury, as if this had a power to ſet the virus on float, and diſcharge it with the fetid ſaliva out of the body. And theſe properties are what makes it ſo readily enter the pores of all metals, adhere to and amalgamate with them, unleſs they abound much with ſulphur or earth; whence iron will not be at all affected by it.

3. The ſolution of mercury in *Aqua fortis*, is a violent corroſive, and will, like a ſolution of gold, turn any part of the body it touches of a purple colour, which cannot eaſily be removed again. It is ſometimes ſucceſsfully uſed, as a cauſtic, to callous or tumefied venereal ulcers; tho it is ſo ſtrong, and cauſes ſuch violent pain, that it ought never to be apply'd to ulcers in the *penis*, where the skin is exceeding delicate and tender. It will inſtantly take away warts, ſmall cancers, and other excreſcences, if cautiouſly and properly applied. A few drops of it diluted with a large proportion of water, makes an admirable, ſafe, and mild coſmetic for red and pimply faces, which are to be waſh'd with this lotion twice or thrice a day; and what is thus uſed, ſuffer'd to dry upon the skin. It is alſo an excellent waſh, thus managed, in caſe of the itch, and all cutaneous foulneſs or ulcers. The *Aqua divina* of *Fernelius* was nothing more than a ſolution of mercury, either in ſpirit of ſalt, or ſpirit of nitre.

*Medicinal virtues of the ſolution.*

4. The vitriol or cryſtals of mercury are, in like manner, the moſt violent corroſive we know; and will inſtantly eat thro the fleſh, to the very bone. The tenth part of a grain thereof, being given internally, would cauſe ſtrange diſorders in the inteſtines, act both as a ſtrong emetic and cathartic, and raiſe a ſalivation in a few hours time. But no prudent phyſician will venture to adminiſter it in this manner, as being violently poiſonous. This vitriol eaſily flows at the fire, has a very diſagreeable nauſeous taſte that long remains upon the palate, and when diſſolved and laid upon copper, inſtantly gives it the whiteneſs of ſilver. Theſe ſeveral virtues and properties of it appear in great meaſure to depend upon the acid, wherewith the heavy body of the mercury is concentrated, and intimately united, or, as it were, ſtuck full of ſharp ſaline

*Vertues, properties, and uſes of the vitriol.*

*spiculæ*, which thus adhering to the globules of the quick-silver, it is thereby made to act powerfully upon every thing wherewith it comes in contact.

## PROCESS CLXXI.

### *Exhibiting the precipitation of* MERCURY *out of* Aqua fortis; *or the preparation of* White Præcipitate.

*The process.* 1. TO *the solution of the foregoing process, made with* Aqua fortis, *add thrice its quantity of fair water, which will cause no cloudiness in the liquor; afterwards pour thereto about twice as much strong lixivium of common salt as there was of the solution of mercury, and the mixture will immediately grow milky, and precipitate a white powder to the bottom of the containing vessel. Then pour the whole mixture, together with the powder already precipitated, into a filtre, and wash the remaining calx, by the frequent affusion of warm water, till what runs from it becomes insipid, and there will a pure, white powder be left in the filtre; which being dried before the fire, is called by the name of the white præcipitate of mercury.*

*The doctrine it affords.* 2. It appears from this experiment, that mercury is readily dissolvable in *Aqua fortis*, but difficultly in *Aqua regia*; which, however, will take up some part thereof. For the water used to wash the præcipitate, carries some mercurial particles thro' the filtre: on account whereof, it becomes a good cosmetic; and for cutaneous disorders is preferable to the *Aqua divina Fernelii*. And therefore, if we were to conclude from this experiment, mercury should seem to approach nearer the nature of silver than of gold.

*Medicinal virtues and uses of the preparation.* 3. This white præcipitate is more powerful in its operation than crude mercury, but more languid than the crystals or vitriol thereof, obtained by means of *Aqua fortis*; as being, by the ablution, in great measure freed from its corrosive salt, and made less caustic; so that it may be safely given internally from three grains to ten *, along with some proper purgative, to determine its operation to the intestines. And thus it becomes an excellent cathartic in all venereal complaints, and where phlegm, or worms are lodged in the body; as also in the itch, or other cutaneous distempers. If taken in small doses, as the quantity of two or three grains, and repeated at proper distances, for some days successively it raises a salivation very well; and upon this account, is held under a disguize, as an excellent panacea of mercury, by many who practise physic: but if given along with something warm, to determine its virtue to the surface of the body, it then becomes a sudorific. Mixed in a moderate proportion with pomatum, or ointment of roses, it makes an admirable unguent for the itch, leprosy, and ulcers of the skin: and

* This medicine is very seldom, if at all, prescribed internally by the *English* physicians, tho, if cautiously used, it is safe enough, and has wonderful virtues in the *Lues venerea*, and cutaneous diseases.

if

if mixed in a ſtill leſs quantity therewith, as in that of a twentieth or thirtieth part, an excellent coſmetic †. And if in making the ſolution of mercury for this medicine, a little copper be added, the precipitate will be of a green colour, and have much the ſame virtues; being emetic as well as purgative, in the quantity of a few grains, and called the green præcipitate of mercury, and by ſome the green lizard.

## PROCESS CLXXII.

### *Exhibiting the red* Præcipitate, *or* Calx *of* MERCURY.

1. *LET the cryſtals of mercury, obtained in the manner of the hundred and ſeventieth proceſs, be expoſed to a ſoft fire, in a proper glaſs veſſel, and gently evaporated, with care to avoid the noxious fumes; and as it increaſes in degree of dryneſs, ſo it will change colour from white to yellow; and at length if kept conſtantly ſtirring, and urged with a ſtrong fire, become of a perfect ſhining red; in which ſtate, being removed from the fire, it is the red præcipitate of mercury, and appears not much unlike to minium.* *The proceſs.*

2. If the action of the fire ſhould be too long continued, it would drive away all the acid, and leave nothing behind but pure mercury, recovered in its native form; and, therefore, is not perfectly fixed by the ſpirit of nitre. This red powder, however, is capable of being conſiderably fixed by repeated diſſolutions and exhalations; tho it will ſtill be recoverable again, and rendered volatile, by violence of fire. This increaſe of the fixedneſs in the calx of mercury, has cauſed ſome chemiſts to call it horizontal gold, or gold in the horizon, and to look upon it as a ſubſtance nearly allied to that metal. *Sylvius* writes, that mercury may be made to afford gold by means of ſpirit of nitre; and *Helmont* had a method of rendring it ſtill more fixed, by mixing it with the white of an egg, and afterwards diſtilling it in a retort: but we do not find that it will thus be made to endure a blaſt-fire. By being mixed with alcohol, and diſtilled in a retort, the remaining matter becomes nore mild and gentle: and when thus treated, it ſeems to be the *Arcanum Corallinum*, or *Saltabrum* of *Paracelſus*. By repeated deflagration with pure ſpirit of wine; it may, as well as by a ſtronger heat, be reduced to mercury again; and, like the white præcipitate, it loſes of its cauſtic virtue by frequent ablution. Whence we ſee it confirmed, that mercury may be uſed in greater quantities, the leſs proportion of acid it is mixed with. *Its nature and effects.*

† This precipitate is found an extraordinary medicine for external uſes, and may be managed to all the deſirable advantages of cleanlineſs, inoffenſiveneſs, and efficacy, either by way of lotion or unguent: and is the grand ſecret of ſome, when diſſolved in water, for curing the itch, or leproſy, and deſtroying all kinds of vermin, without daubing the linen, or giving any offenſive ſcent. But where there is any rawneſs, it ought either to be well edulcorated, or mixed in a very ſmall proportion with other ingredients, otherwiſe it will cauſe a conſiderable pain or ſmarting.

*Medicinal virtues and uses of the production.* 3. This red calx, improperly called præcipitate, is ſtronger and more corroſive than the white præcipitate of mercury, and purges violently both upwards and downwards, in half the doſe of the other: being generally uſed for much the ſame purpoſes with that. But as it is apt, by its corroſiveneſs, to corrode and exulcerate the ſtomach and inteſtines, I cannot recommend the internal uſe thereof; tho it appears to have been the medicine ſo ſucceſsfully employed by the woman at *Paris* in deſperate venereal caſes, given over by the phyſicians of the place. She ordered it in the quantity of eight or ten grains, to be taken every morning, for three or four days running; by which means it firſt vomited, then purged violently, and laſtly ſalivated; and ſometimes too it killed the patient, when he happened to be weak. The like effect may likewiſe be produced by turbith mineral. 'Tis highly valued by chirurgeons as an internal for taking down fungous fleſh, cleanſing foul ulcers, drying up their moiſture, and diſpoſing them to heal.

## PROCESS CLXXIII.

### *Exhibiting the* Solution *of* MERCURY *with oil of vitriol.*

*The proceſs.* 1. *TO a proper quantity of well purified quick-ſilver, put into an urinal, pour four times its weight of good oil of vitriol, and ſet the veſſel in an open fire; upon which a copious, white, and very deſtructive fume will aſcend, and the whole body of the mercury be converted into a white calx or powder; let the matter continue upon the fire, taking care to avoid the noxious vapour, till it almoſt ceaſes to ſmoke, or be turned to a grey powder; which is the mercury it ſelf diſſolved by the oil of vitriol, and rendered moſt violently corroſive, fiery, and poiſonous.*

*Its nature; with that of the production.* 2. The oil of vitriol, in this caſe, does not, like ſpirit of nitre, reduce the mercury to a ſalt; and will ſcarce act at all upon it, without the aſſiſtance of a conſiderable heat, how long ſoever it ſtands thereon; which may let us ſee that ſome menſtruums will not act till put into motion by ſome general cauſe; as for inſtance, by the air, fire, water, trituration, &c. and indeed the ſolution will never be perfect unleſs the matter be made to boil. A thin glaſs, or urinal, is more proper for this operation than a retort, which will not ſo well endure the fire, and might, upon breaking, prove of dangerous conſequence; for the fumes are ſuddenly ſuffocating, as the preparation it ſelf is highly and immediately poiſonous if received into the body; being a moſt violent acid lodged or concentrated in the body of the metalline mercury: whence it is eaſy to account for its corroſive power. It is the moſt corroſive and fiery of all the preparations of quick-ſilver, except the following; and has ſcarce any medicinal uſe, unleſs it be to ſerve the purpoſes of chirurgery, and in the preparation of *turpethum minerale.* Leſs than

than a grain, being received into the stomach, might cause a vomiting of blood, a dysentery, bloody urine, a salivation, and death.

## PROCESS CLXXIV.

### *Exhibiting the fiery* Oil *of* MERCURY *when dissolved with oil of vitriol.*

1. *TO the grey powder of the preceding process, add an equal weight of good oil of vitriol, and again expose it to the fire, and treat it as there mentioned; by which means the mercury will again be totally dissolved into a thick, ponderous liquor, and exhaled to a powder; which, by several times repeating the operation, will at length be brought into so fixed an oil, that the heat of ebullition, or even the most violent fire, can hardly dry it; and so strong a caustic, that it may justly be called the fiery oil of mercury.* *The process.*

2. The fumes arising in this process are to be carefully avoided, as highly poisonous and destructive to the lungs. The oil it self is the strongest corrosive yet known in the world, or that, perhaps, can possibly be made; whence 'tis aptly enough called *ignis Gehennæ* by *Paracelsus*; scarce any thing being able to withstand its force. This, however, is not the metallic oil of the adept; because it is joined with a menstruum, whereas that ought to be perfectly pure and unmixed; but the experiment will serve to shew us how acids may be concentrated with the mercurial part of metalline bodies, into the most violent, corrosive oils in nature; which being once dried by the long continued action of a vehement fire, will remain fixed therein, or even almost endure a blast-heat: and this, therefore, shews us an approximating method of fixing mercury. And perhaps all fixation of metals may be owing to nothing more than the strong union of their parts with a ponderous acid salt, which will not easily suffer their texture to be broken *. *The caution it requires; with its nature and use.*

3. The medicinal uses of this fiery oil are not very considerable, unless in chirurgery, where it may serve for extirpating cancers, or the like: but no one would ever dream of giving it internally. I make no question but an exceeding small quantity of it, being received into the stomach, would instantly dissolve its substance, or forcibly tear it to pieces. *Uses of the production.*

* Whether it be salt or sulphur that fixes the mercury of metals, has not yet been made evident by undeniable experiment; but the diligent M. *Homberg* affords us many curious observations which tend to shew it is sulphur; or, in other words, the matter of light. Yet all metals seem to contain a latent salt; by means whereof their terrestrial part is thought, by strong fusion, to be convertible into glass.

## PROCESS CLXXV.

### *Exhibiting the preparation of* Turpethum minerale, *from the solution of* MERCURY *in oil of vitriol.*

*The process.* 1. *UPON the dry powder gained by dissolving mercury in oil of vitriol, after the manner of the last process but one, pour a proper quantity of warm rain-water; and the powder will immediately turn of a yellow colour. Continue to wash this powder by repeated affusions of water, till the liquor comes away as insipid and colourless as it was poured on, leaving a beautiful yellow calx at the bottom of the vessel; which being gently dried at the fire, is called by the name of* turbith mineral.

*Nature of the production.* 2. This powder is called *mineral turbith*, from the resemblance it bears to the vegetable turbith of the *Arabians*, in strongly purging the most internal recesses of the body: for, tho it be insipid upon the tongue, yet it is possessed of very considerable virtues. Being boiled with water, it loses more of its salts, and thereby grows milder and more safe: so it does by being deflagrated twice or thrice, or distilled with spirit of wine.

*Its medicinal virtues.* 3. A very few grains of this turbith will prove emetic and purgative: it is also accounted a most excellent medicine in the cure of the venereal disease. But as it operates with considerable violence, it ought not to be given unless the viscera are known to be sound. This seems also to be the mercurial powder mentioned by Mr. *Boyle*, as received in a very small quantity at the nose, by way of snuff, whereby a certain captain was perfectly cured of a total blindness, caused by cataracts; the medicine operating by sternutation, vomit, stool, sweat, urine, and salivation, for a very long time together. But this universal manner of operation is not peculiar to turbith mineral; all the præcipitates of mercury will do the same, when snuffed up the nostrils; but their operation is so violent, and the disorders they cause so intolerable, and succeed so fast, that it is shocking to think of prescribing them in this manner. This likewise appears to have been the grand secret of *Paracelsus*; which, in his scarce *German* book of hospital medicines, he praises so extravagantly for venereal and all chronical diseases. *Sydenham* also commends it in venereal cases, given in the quantity of six or eight grains, in strong habits of body, so as to prove emetic: but when imprudently used, it is apt to give the dysentery.*

PRO-

* Here might properly follow the preparation of corrosive sublimate of *mercury*, and from thence of *Mercurius dulcis*, in order to complete the series of processes made upon mercury with salts, before we are conducted to those performed upon it with sulphur. But the process for making this mercury sublimate, being omitted by our author as no part of his design, it may be supplied in the following manner.

*Preparation*

## PROCESS CLXXVI.

### *Exhibiting the Reduction of* MERCURY *into* Æthiops mineral, *with Sulphur.*

1. TAKE *equal weights of purified quick-silver and flowers of sulphur, and grind them well together in a stone mortar, till the globules of mercury become invisible, and the whole mixture is turned to a black powder; that is, till the body of the mercury is intimately united with the sulphur; which then makes what is called* Æthiops mineral, *and improves in blackness the longer it is ground.* *The process.*

2. It appears by this process, that sulphur may, in the mines, readily unite with fluid mercury, and form a fixed, black mass, of a nature entirely different from both; which, however, is accounted the best ore of quick-silver. The way to recover the mercury out of this powder, or black mineral glebe, is to grind it with an equal quantity of iron filings, and then distil it with a strong fire, in an iron retort, which will send over the mercury revived and purified. *Its physical use.*

3. This black powder, tho taken in very large quantities, will not salivate like other preparations of mercury, and indeed cannot be dissolved by any of the animal fluids; whence it can scarce possibly enter the lacteals, but runs untouched thro' the intestines: by which means, however, it may gently stimulate their coats, sollicit a discharge of their contents, destroy the worms it meets with there, and serve to cure such disorders of children as proceed from causes seated in the *primæ viæ*; for which last purpose it is found very effectual. In other respects it seems to be unactive in the body; the mercury lying dormant in the sulphur, and requiring to be mixed with purgative or other proper ingredients to bring it into action; by which means it may be rendred serviceable in cutaneous, phlegmatic, or venereal diseases; the cure where- *Medicinal virtues of the production.*

*Preparation of the corrosive Sublimate of* MERCURY.

GRIND *together equal quantities of clean mercury, revived from cinnabar, calcined vitriol, nitre, and decrepitated salt, till the globules of the mercury become invisible; then put the mixture into a glass retort, and sublime by degrees of fire in a sand-furnace. When all is cold, let the glass be broken with care to avoid the poisonous fumes, or light dust that may arise, and take away the sublimate adhering, in the form of a white glebe, to the sides thereof; which may again be sublimed with an equal weight of oil of vitriol, and decrepitated salt, to render it more corrosive.*

This sublimate is a very violent poison, and proves mortal in the quantity of a few grains: it is, therefore, never used internally. But when dissolved in lime-water, it makes a good lotion for foul, eating ulcers, the itch, and other cutaneous diseases. It likewise serves to take down fungous flesh, and answers other purposes in chirurgery. Its principal use is the share it has in the preparation of that excellent medicine, *Mercurius dulcis*; which is made by grinding fresh mercury with it, and repeating the sublimation till the points of the salts are broken fine, or till the sublimate becomes sufficiently mild, and fit for internal use.

of it would never otherwise effect; contrary to the opinion of those who imagine the virtues of mercury to be exalted and raised when brought into such a state of inactivity, as renders it incapable of raising a salivation, by being made too gross or insoluble to enter the lacteal vessels, and mix with the blood.

## PROCESS CLXXVII.

### *Exhibiting the preparation of artificial* Cinnabar *of* MERCURY, *with sulphur.*

*The process.*

1. TAKE *of Æthiops mineral, made after the manner of the foregoing process, with one part sulphur and three of mercury, and put it into an earthen, or* Hassian *cucurbit; carefully lute on a glass head, or receiver thereto, and sublime the mixture in a strong heat of sand, and the mercury will ascend along with the sulphur, and adhere to the sides of the glass in form of a fine red glebe, or artificial cinnabar, not to be distinguished in any respect, when reduced to powder, from the native cinnabar of the mines.*

*Varied; with the medicinal uses of the production.*

2. The process may otherwise be performed by first fusing the sulphur, and mixing the mercury with it by degrees, which will then fulminate therewith: after this, the vessel being close covered and set to cool, the ingredients will be found run into a black mass, which, being ground to powder and sublimed, affords a beautiful cinnabar. In this preparation the mercury adheres more loosely than in the mineral æthiops, as will appear by the microscope; and therefore may sometimes raise a salivation. But if it be well and perfectly made, there is no danger thoreof; for in that case it does not seem capable of entring the lacteals, tho it proves something more active in the first passages than æthiops mineral; and answers much the same intentions, being frequently used for worms, and by some for fits in children. In order to revive or recover the mercury again from this cinnabar, it need only be distilled from fixed alkali; which keeps the sulphur behind, and lets the quick-silver go over pure.

## PROCESS CLXXVIII.

### *Exhibiting the* Amalgamation *of* MERCURY *with Lead.*

*The process.*

1. MELT *a proper quantity of pure lead in an iron crucible; remove the vessel from the fire, and when the metal is a little cooled, pour to it an equal weight of clean mercury, which will immediately enter the lead with a hissing noise. Then stir the mixture well together with an iron rod, and, when cold, it will appear in the form of a softish, brittle mass, called the amalgam of mercury with lead.*

2. 'Tis

2. This shews us the general method of amalgamating metals with mercury; all which, except iron and copper, will readily unite therewith: but gold with the greatest facility, silver with the next, then lead, tin, and copper; but it will scarce unite at all with iron. Whence we see that the affinity is greatest between mercury and the least sulphureous metals; and in particular that it may readily be adulterated with lead. Metalline bodies being thus made soft, or reduced to an amalgam, are fit for various uses, both in chemistry and other arts: thus, in particular, the art of gilding entirely depends upon it. If gold be amalgamated with quick-silver, and the mixture conveniently laid upon any other metal, as copper for instance, and this afterwards be placed upon the fire, the mercury will thereby be evaporated, and the gold alone left upon the surface of the brass; that is, the brass will thereby be gilt with gold. *Its physical use.*

3. If this amalgam of mercury and lead, which appears of a bright, silver colour, be well washed, and ground with fair, warm water, in a glass mortar, a copious black powder, or earth, will mix it self with the liquor; and if fresh water be several times poured on, and the ablution repeated, there will at length be obtained, as it were, a kind of silver, or universally a much purer substance than that employed in the amalgam; tho it will not become perfectly pure, how much soever it be washed, the water still growing black in the operation. 'Tis one of the greatest secrets in chemistry, to bring this liquor off as clear and unsullied as it was poured upon the amalgam; and might afford a method for making the nobler metals, or procuring them from the baser. Indeed this philosophical method of purifying metals, is it self no inconsiderable secret; especially as it may be applied to the purging of all metalline bodies, and even gold; which likewise may be made to deposite a black powder in the operation: whence mercury has been called the bath, or cleanser of metals. The powder gained by evaporating the several washings of the amalgam, has frequently been called the earth of the metal that affords it, but improperly: it seems rather to be the sulphur adhering to the metals, mixed with a part of their own mercury, or the quick-silver employed in the amalgamation. *The process carried higher.*

4. The result of our several processes upon metals, is in short this. We are taught by them that metals can scarce at all be brought to act upon the body, but by means of salts, and particularly such as are acid and violently sharp, which dissolve and convert them into vitriol; that their power is always the greatest, as they contain the larger quantity of this acid, which being driven away from them, ground finer, or having its points broken, leaves them less active proportionably: and lastly, that this may be effected by long digestion, and ablution with water, precipitation, deflagration with spirit of wine, and thorough calcination. And thus at length we have finished the chemical history of metals; and are thereby prepared to enter upon the treatment of semi-metals, the subjects of our last link of processes; which we *Recapitulation of the doctrine afforded by the history of metals.*

ſhall deliver in the ſame geometrical order as hath hitherto been obſerved *.

# CHEMICAL HISTORY *of* SEMI-METALS.

*Introduction to the hiſtory of* Semi-metals.

SEMI-METALS are diviſible into two kinds; thoſe which conſiſt of a metal joined with a ſalt, as native vitriol; and thoſe compoſed of metal and ſulphur, as antimony: by the treatment, therefore, of theſe two, we ſhall endeavour to ſhew the method of treating all the bodies of this claſs, ſo as to give the chemical hiſtory thereof.

* This chemical hiſtory of metals will ſcarce be thought complete by the generality of our readers, however agreeable it was to the author's deſign, without taking the leaſt notice of gold, the nobleſt among them. We will here, therefore, juſt mention the more remarkable experiments uſually performed upon it. There are four different ways of purifying, or ſeparating it from other metalline bodies, wherewith it may happen to be mixed; *viz.* by the cupel, the depart, cementation, and melting it with antimony. When by any of theſe means it has been made thoroughly fine, and fit for chemical uſe, it may be reduced to powder, for ſeveral purpoſes, or rendered potable and volatile various ways, as particularly by amalgamation, mixing with other bodies, diſtillation with certain menſtruums, *&c.* and may, if a perſon has the ſkill, be chemically treated with as much eaſe as ſilver; and be converted into a variety of medicines, to greater advantage, perhaps, than phyſicians are generally aware of. The proper ſolvents for it are vulgarly eſteemed ſpirit of ſea-ſalt, and *Aqua regia*, by means whereof the *aurum fulminans* is made; this being no more than the calx, or powder of gold, precipitated with oil of tartar, or ſpirit of ſal-ammoniac, out of a ſolution of that metal made in *Aqua regia*; and carefully dried before a gentle fire, to prevent its running together, and going off with a loud report, as it is very apt to do with a conſiderable heat; the acid ſpirit of the menſtruum being thereby rarified, and breaking forcibly thro' the tenacious, metalline particles, wherein, by the operation, it was lodged and impriſoned: which is the common way of accounting for this ſtrange phænomenon. But the great price of the ſubject having proved a general hindrance to making the finer experiments thereon, whoever deſires to ſee what uncommon things are performable with it, when treated by a judicious chemiſt, may conſult the excellent Mr. *Boyle* upon that head, in different parts of his philoſophical writings.

CHE-

# CHEMICAL HISTORY *of* VITRIOL.

## PROCESS CLXXIX.

*Exhibiting the analysis of* VITRIOL; *or its calcination, and reduction to Spirit, Oil, and Colcothar.*

*The process.*

1. PUT *any quantity of good* Hungarian *vitriol into a proper, unglazed, earthen pot, and set it in the middle of a strong fire, till the matter melts, ceases to fume, or becomes dry and white; and this is called calcining of vitriol to whiteness.* (2.) *Grosly bruise this calcined vitriol in a mortar, and with it fill two thirds of an earthen retort, that is able to endure the strongest fire, and apply, with a proper lute, a capacious receiver thereto.* (3.) *Set the retort in a reverberatory-furnace, gradually raise the fire, and at first there will come over, in strong fumes, a spirit of vitriol, for four or five hours; then increase the heat to the greatest degree the furnace will bear, and continue it for twelve hours at the least; by which the more ponderous acid, or oil, will be brought over into the receiver; leaving a whitish mass, called colcothar, at the bottom of the retort* *.

*Cautions and directions relating to it.*

2. Vitriol cannot, with prudence and safety, be analysed but in a spacious place, and with the utmost attention, to prevent the mischievous effects that might arise therefrom. In order to procure the acid of vitriol to advantage, the mineral need only be calcined as the process directs, and reduced to gross powder; after which, being by it self exposed to a violent fire, it yields first its spirit, and then its gross, ponderous oil. There is no occasion for the addition of any bole, or the like material, to separate the parts of the vitriol in distillation; because, as all metalline and stony salts naturally contain something which prevents their fusion at the fire; so vitriol contains colcothar, or a metallic earth, which, interposing between the saline particles, keeps them from running together. And the stony earth contained in alum, performs the same office in the distillation thereof. It is farther remarkable of vitriol, that tho urged with ever so violent a fire, it seems never to afford all its acid. I once pressed a parcel of it strongly, with a very intense degree of heat, for four days and nights together, so as continually to keep the retort red-hot for all that time; yet, when after this I had suffered the vessels to cool, and coming to take the receiver from the retort, a copious, suffocating, acid fume ascended out of the latter: whence it may be concluded, either that vitriol does not give all its acid in such an operation; or that the

* This colcothar, being calcined in a strong fire, turns blood-red, and becomes the famous styptic, commonly called *calcanthum rubefactum.*

*caput mortuum*, or colcothar, after the action of fire has ceased, draws back again to it self some part of the acid before driven over into the receiver. And, indeed, this suspicion can hardly ever be avoided, but by taking away the receiver in the time of distillation, whilst the vessels are hot: tho this cannot be done without greatly endangering the life of the person who shall attempt it, by the suffocating fumes which are then plentifully rising.

## PROCESS CLXXX.

### *Exhibiting the preparation of Tartar of* VITRIOL.

*The process.*

1. G*RADUALLY, and at several times, for fear of too much increasing the heat and commotion, mix one part of oil of vitriol with twice its weight of fair, hot water; and into the mixture drop, by degrees, as much oil of tartar, run* per deliquium, *as will serve to saturate the acid liquor: at each affusion a great ebullition will be made; and after this ceases, or the exact point of saturation is gain'd, a white saline matter, not easily soluble in water, will be precipitated to the bottom of the containing vessel: then the liquor that swims above it, which is of a saltish, but not sharp taste, being first diluted with more hot water, then decanted, filtred, and exhaled to a pellicle, will, in a cold place, shoot into white crystals, that are neither acid nor alkaline, in figure perfectly resembling genuine vitriol, as we before observ'd of sea-salt; but having no manner of colour, unless some metalline part adheres thereto. And this salt, thus prepared, is called* tartar of vitriol; *and appears to be no more than a regeneration of that native fossil, or the saline part thereof.*

*Directions relating thereto; with its physical and medicinal uses.*

2. The purer the oil of vitriol, and oil of tartar employ'd in this experiment, the purer the crystals appear. And great care should be taken not to make the salt too acid, when it is design'd for medicinal uses, as it would be by witholding the proper quantity of the oil of tartar. But when the proportion is exactly hit, these two very sharp and opposite liquors unite into a harmless, neutral, mild, and inoffensive salt, tho much more ponderous than nitre or sea-salt; to which ponderosity its superior medicinal virtues, above other salts, appear to be considerably owing, when it comes to mix with the blood and juices: and on this account it is reckoned more effectually aperitive than they. And indeed it admirably, and particularly serves to deterge the vessels of the body, cleanse and disburden the first passages, and open obstructions: it also dissolves so powerfully, that it has gained the name of the universal digester. It may be taken, for these purposes, from five to thirty grains, in a mess of broth, or the like. And hence we are furnished with another clear instance, that one exceeding sharp and violent liquor may so correct and mortify another, as to render it innocent, tho of it self it were destructive to the body; and consequently, that two strong poisons may be antidotes to each other. Thus for instance,

instance, a small quantity of mercury sublimate, taken into the body, would of it self prove suddenly mortal, on account of the acrimony it has from the acid of the sea-salt that enters its composition; whereby it might, in the space of a few minutes, corrode and eat away the membrane which lines the stomach, and cause a gangrene in the part: but if a proper quantity of oil of tartar, made *per deliquium*, be drank immediately after it, this will presently draw to it self, and absorb the acid of the sea-salt, and thereby turn it to sea-salt again, which is no way mischievous to the body; and at the same time suffer the calx of the mercury to remain of an innocent nature; whence the person would receive no harm. And here we may draw this general and useful conclusion, that salts do not act in the body according to what they are at the time they were taken; but according as they meet with other salts, which determine their action in the body. So that it is very unsafe and difficult to assign the action of some medicines given together in composition; or even tho given the one some time after the other.

3. This process, also, gives us to understand the nature of that acid which, in the mines, dissolves metalline bodies into vitriolic substances; and that the metal in this case acts like the fixed alkali in our present process: for when this acid is joined with iron, it turns that metal into those saline glebes which commonly go by the name of vitriol, or copperas. And if this acid be again, by fire, forced from the metalline part, it leaves a colcothar, that is, calcined iron behind it; tho some portion of the metal it self is also carried up in the operation; from whence proceeds the colour and ponderosity of oil of vitriol. And if spirit of sulphur *per campanam*, be poured to oil of tartar made *per deliquium*, a vitriol will thus also be produced; which seems to prove, that the native acid of mines is of the same nature with the former. And indeed it is probable, that there is but one kind of native mineral acid; which, being joined with iron, gives a green vitriol, and with copper, a blue; with chalk appears in the form of alum, and with oil composes sulphur, and various kinds of bitumen. *The physical doctrine it affords.*

## PROCESS CLXXXI.

### *Exhibiting the preparation of* Ens Veneris *from the Colcothar of* VITRIOL.

1. CALCINE *the colcothar that remains after the distillation of oil of* Hungarian *vitriol, in a strong, naked fire, for twelve hours, or longer, till it becomes a light powder, of a deep red colour; then take this powder from the fire, and boil it with fair water in a glass vessel; pour off the water impregnated with the colcothar, and put on fresh, and repeat the operation* *The process.*

*tion till the liquor comes off as clear and inſipid as it was poured on. Let the dulcified powder now be dried, and then well ground with twice its weight of dry ſal-ammoniac; next ſublime the mixture with a proper degree of heat; and after a volatile, and very piercing water has riſen, red flowers will aſcend, in the manner of thoſe of ſulphur, and adhere to the ſides of the ſubliming veſſel; which being taken out, are what is called* Ens Veneris.

*Its phyſical uſe.* 2. This proceſs ſhews us, that a body which has endured the utmoſt violence of the fire, and ſtill remained fixed therein, may nevertheleſs be rendered volatile by means of ſal-ammoniac: and the ſame calx, if ſuffered to remain in the open air, will, by attracting the moiſture thereof, form it ſelf, as it were, into vitriol again.

*Medicinal virtues of the production.* 3. Theſe flowers have been highly valued for their medicinal virtues; and particularly the excellent Mr. *Boyle* recommends them, from his own experience, as a ſpecific for the rickets in children. By being expoſed to the open air, they will run into a liquor, or tincture of copper, which may conveniently be given, by way of drops, in ſuch caſes as require the aſſiſtance of that metal.

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## CHEMICAL HISTORY *of* ANTIMONY.

*Introduction to the hiſtory of Antimony.* THE ſtibium of the antients is the antimony of the moderns; being a foſſil glebe, compoſed of an undetermined metal, a ſulphureous, and a ſtony ſubſtance. The beſt is that found in gold-mines, where it is likewiſe obtained in greateſt plenty. When dug out of the earth, it is put into large crucibles, fuſed at a violent fire, and then poured into cones, or antimonial horns: which makes the common antimony of the ſhops; the apex whereof is always the beſt and pureſt part, as the baſis, or broader portion, is the fouleſt. Sometimes antimony is found to contain veins of a red or golden colour, and then 'tis called male-antimony; but when it is without them, female: tho this difference depends entirely upon the ſulphur adhering to it. Among the chemiſts it goes by various names, as black-lead, philoſophical lead, or Saturn, the bath of the king and queen, all in all, *&c.* In its crude ſtate, or when barely reduced to powder, it is poſſeſſed of no purgative or emetic virtue; but if taken in a very large quantity, it gently ſtimulates the inteſtines; and is accounted an excellent remedy to cleanſe the blood of horſes and other cattel. But when added, in the lump or groſly bruiſed, to diet-drinks, it ſeems to communicate very little virtue, or ſcarce more than a common ſtone, thereto.

PRO-

## PROCESS CLXXXII.

### *Exhibiting the Solution of* ANTIMONY *in* Aqua regia.

1. R*EDUCE antimony to gross powder, put it into a warm glass, and pour thereon, at several times, twice its weight of* Aqua regia*; a violent ebullition will immediately arise, with suffocating red fumes, which are carefully to be avoided, and a considerable heat. After the ebullition is over, the metalline part of the antimony will be found at the bottom, in form of a grey powder; a mass of yellow matter appearing on the top.* *The process.*

2. This operation is termed the humid calcination of antimony; and may serve to shew, so far as the proof will hold, that this semi-metal approaches nearer to the nature of gold than of silver; as being, like gold, dissolvable in *Aqua regia*. *Its use.*

2. If the powder, into which the antimony is here dissolved, be gently dried at the fire, it becomes most violently corrosive, purgative, and emetic, and capable, in the smallest quantity, of causing very great disorders in the body; so that it cannot be given internally with any manner of safety. *Nature of the production.*

## PROCESS CLXXXIII.

### *Exhibiting the method of procuring the Sulphur of* ANTIMONY.

1. T*O the solution of antimony, made with* Aqua regia, *pour a quantity of fair water; and the yellow matter, mentioned in the last process, will be made entirely to leave the metalline part at the bottom, and float on the surface; so that it may be readily taken off with any convenient instrument. And if this be well washed in several waters, and afterwards melted at the fire, it will appear in the form of sulphur, hardly distinguishable from the common.* *The process.*

2. The separation of the antimony into two distinct parts, a metalline and sulphureous, in this process, appears owing to that property of acid spirits, whereby they readily dissolve metals, but act not at all upon sulphur, which abounding in antimony, is set free when the acid dissolves the metal; this sinking to the bottom, and the lighter unctuous matter rising to the surface. The subsiding powder is so far of a real metalline nature, that being thus freed from its sulphur, it may, by strong fusion, be made into a pure regulus of antimony. And the yellow matter taken off from the surface, is so really sulphur, and so far from partaking of a metalline nature, that it burns with a blue, suffocating flame, and scarce wants any one property of common brimstone. And *Its nature and use.*

to this ſulphureous part of the mineral are entirely owing many of its phænomena, as we ſhall ſee hereafter. Whoever, therefore, expects any particular virtues from the ſulphur of antimony, different from thoſe of common ſulphur, will find himſelf miſtaken; how much ſoever the contrary opinion may have prevailed. And hence we learn, that common ſulphur may be intimately united to mineral glebes, or the parts of metalline bodies, and lie concealed, in conſiderable quantities, therein; ſo as not to be diſcovered by the bare action of the fire; tho they may readily, by means of an appropriated menſtruum, be made to yield out one third of their own weight of viſible ſulphur.

## PROCESS CLXXXIV.

### *Exhibiting the method of purifying* ANTIMONY *by ſimple Fuſion.*

*The proceſs.*

1. *BRUISE a quantity of common crude antimony, and thorowly fuſe it, for an hour, at the fire, in a crucible, without any addition; it will readily run, and at the ſame time afford white, ſuffocating, ſulphureous, or arſenical fumes, which are to be carefully avoided. Remove the crucible from the fire, and ſuffer it to cool; frequently ſhaking it at firſt to make the metalline matter ſettle; break the veſſel when it is quite cold, and you will find the matter divided into two parts; the uppermoſt being a brittle ſcoria, or light ſpongy droſs; but the other a ponderous, metalline maſs; which, when ſeparated from the former, is called regulus of antimony* per ſe.

*Its phyſical uſe.*

2. This proceſs ſhews us another quick method of purging metalline glebes, or ores, of their ſulphur; moſt of which may, at the ſame time, by ſimple fuſion, be cleared of the ſtony and other heterogeneous matter that is apt to adhere thereto; the lighter bodies riſing to the ſurface, and conſtantly leaving the heavier metal at the bottom of the crucible. If you deſire to preſerve the veſſel wherein the matter is fuſed, pour out the whole, whilſt it remains in fuſion, into a dry cone or ingot, greaſed on the inſide; which will cauſe it to come out the eaſier when it is cold. And if this proceſs be ever ſo often repeated, there will a new ſcoria be thrown off; whence the regulus becomes the purer.

PRO-

## PROCESS CLXXXV.

*Exhibiting the method of purifying* ANTIMONY *with flux-powders; or the common method of reducing it to a Regulus, at one operation.*

1. TAKE *of good antimony eight parts, of tartar five or six parts, and of nitre three or four; grind them to powder separately, then mix them well together, and throw them, by a small quantity at a time, into a nealed or ignited, open crucible: at every injection there will be a strong detonation, and a flashing like that of gun-powder. When the mixture is, by this means, all thrown into the crucible, cover it with a tile, and put it into a strong fire of fusion, and make the matter run like water for about half an hour; then remove the crucible from the fire, and pour out the matter into a melting-cone that is dried, greased, and heated for the purpose. Keep knocking the cone a little, to make the metal subside; and after it is cold, beat out the matter; upon which the sulphur of the antimony will be found, mixed with the salts, in the form of a scoria at top, and the regulus, or metalline part, pure and shining like silver, at the bottom; which may be easily beat from the former by the hammer.* *The process.*

2. The quantity of the flux-powders ought here to be proportioned to the sulphur contained in the antimony; it being their office and use to dissolve it, and get it away from the metalline part thereof. Great care must be had in throwing the mixture into the ignited crucible; for if the quantity injected at once be too large, and fresh be added before the detonation of the former, it may grow crusty on its outside; in which case, when the internal parts come to be ignited and rarified, the whole mixture might be blown away, and scattered around to a very considerable distance; and thus prove as mischievous as a little mine of gun-powder. And the like care is required to keep the fire equable in its strength, to prevent the matter in fusion from cooling and growing crusty on its surface; which might also be of very bad consequence. No less caution is required in well drying, heating, and carefully greasing the cone, into which the melted matter is to be poured; for if a single drop of water should be lodged therein, it would break the vessel to pieces, and throw them off with a very great violence. And to prevent any ill accident from this cause, it will be proper never to use oil, which always contains some proportion of water; but well purged tallow, or other unctuous substance, that is perfectly free from all aqueous moisture. *Directions relating to it.*

3. We have already seen, that antimony is principally composed of sulphur and metal; whence it will be easy to account for its depuration in the manner of our present process: for both tartar and nitre instantly change to an alkaline nature in the fire, and powerfully attract and drink in sulphur, like fixed alkali, leaving the metal untouched: *Its doctrine and use.*

whence it is evident that the ſcoria in this operation is mere ſulphur, thus diſſolved by the fluxes, and thrown to the top from the heavier metal. And this ſhews us the general method of purifying all ſorts of metalline glebes, or bringing them to a regulus, by means of fluxes, as they are called at the mines; and, in particular, it gives us another method of freeing ſemi-metals of their ſulphur; from which, if antimony could ever be perfectly ſeparated, we might then know what kind of metal it contains: but this is no eaſy task, tho it may be approximated for ever. And when, by repeated fuſions with freſh fluxes, the regulus arrives at a conſiderable degree of purity, it commonly repreſents the figure of a ſtar upon its upper ſurface.

*Virtues and uſes of the production.* 4. The ſcoria found at the top of this regulus is violently emetic, as well as the regulus it ſelf; whereof, if cups or drinking veſſels be caſt, the wine that is put into them will become vomitive. And of this regulus, caſt in moulds, are alſo made thoſe commonly called the antimonial pills, weighing about eight or ten grains each; one of which being ſwallowed, will operate conſiderably both by vomit and ſtool. And theſe pills having thus performed their office, and being diſcharged the body, will ſerve for the ſame purpoſe again and again: whence they have obtained the name of *perpetual pills.* The virtue of this regulus is not, however, inexhauſtible, as has been imagined: for by repeated infuſions in wine, tho the liquor be made violently emetic at firſt; yet by degrees it loſes its force, and at length ceaſes to be vomitive.

## PROCESS CLXXXVI.

*Exhibiting the purification of* ANTIMONY, *by means of ſalts and metals; or the preparation of the* Regulus Antimonii, *or* Regulus martialis ſtellatus philoſophorum, *by four operations.*

### OPERATION I.

*The proceſs, part the firſt.* 1. PUT *a proper quantity of pure iron, ſuch as that of the nails wherewith horſes are ſhod, into a ſtrong crucible; ſet it in a wind-furnace, and when the metal is thorowly ignited, put in double its weight of fine-ground antimony; then make a fire of fuſion, and add, by ſmall quantities at a time, ſomething leſs than half as much dried nitre as there was iron. After every injection of the nitre, wait for the detonation, and prevent the matter from growing cruſty on the ſurface; otherwiſe it might blow up the furnace. When the whole quantity of nitre is thrown in, and the laſt detonation is over, cover the crucible with a tile, and ſurround it with a vehement fire, to make the matter flow, like water, for ſome time; laſtly, pour it out into a melting-cone, firſt heated, dried, and greaſed, as directed under the laſt proceſs; upon which the metalline*

*metalline part of the antimony will be found at the bottom, and the lighter scoria at the top, as is there also mentioned.*

2. It is the nature of iron in fusion to be strongly attractive of sulphur, as we formerly observed, when run together into one mass; so that in this operation the iron first powerfully absorbs and dissolves the sulphureous part of the antimony, and turns with it into a light crocus; upon which the nitre being fulminated, and causing a strong flux of the matter, the metalline part of the antimony falls by its own superior gravity to the bottom. And as in this case the iron attracts the sulphur much stronger than the fixed alkali, or the fluxes used in the preceding process, it appears plainly that the antimony must obtain a greater degree of purity by this operation, than by that. And this is the method used at the mines, of purging metals of their sulphur, or extracting from them their sulphureous soul, as the artists affect to speak; who, therefore, generally call iron the magnet of sulphur. The scoria thrown to the surface in this operation, is violently emetic, and will presently run *per deliquium* in the open air. The regulus, likewise, if infused in wine, will readily communicate a vomitive faculty thereto. *Its nature; with that of the production.*

## OPERATION II.

3. *PUT the regulus gained by the preceding operation into a new, clean crucible, and set it in the fire again; when the matter flows, as it readily will, add to it as much fine powder of crude antimony as there was nitre used before; and when these run, put to them, by degrees, the same quantity of well-dried powder of nitre as was added in the first operation, and with the same caution as is there given. After the matter has, by a strong fire, been made to flow as before, pour it out into a cone, dried and prepared to receive it; by which means there will again be obtained a regulus and a scoria; but a regulus much purer than the former, and containing no iron; all that remained thereof being here joined to the fresh, additional antimony.* *The process, part the second.*

4. The regulus of this second operation must therefore partake more of the nature of antimony than the former. The *scoriæ* also of this second process, consisting of nitre, sulphur, and iron, are wonderfully sharp and vomitive, of a more golden colour than the first, which is almost black, and will readily run in the air. *Nature of the production.*

## OPERATION III.

5. *To the regulus of the second operation, put into a new crucible and melted again, add the same quantity of dry, pulverized nitre, in the same manner; which also will make a kind of detonation: this being over, let the matter flow in a strong fire, and then pour it into a cone, as before. And by this means the regulus will again become much purer, more metalline, or approaching more to silver, than the former.* *The process, part the third.*

*Nature of the production.* 6. The scoria, likewise, in this operation, is of a gold-colour, and in the air will run, with great facility, into a yellow or golden liquor, or oil, that is exceedingly corrosive and still emetic; as also is the regulus it self, either taken alone, or infused in wine.

## OPERATION IV.

*End of the process.* 7. *Take this third regulus, put it into a new crucible, melt and fulminate it again with the same quantity of nitre; then make up a stronger fire around it than was used in the preceding operations, or the strongest the furnace will bear; and when it has thus remained for a quarter of an hour, at least, in fusion, pour it into a melting-cone as before, and there will be obtained a very pure and ponderous, metalline regulus of antimony, purged of all its external sulphur, but still retaining enough of the internal to render it brittle: and if the operation was well performed in all its parts, the production will exhibit the resemblance of a star upon its surface, and more internal parts.*

*Nature of the ultimate production.* 8. This regulus seems to want nothing but malleability to make it an excellent, white, sonorous, shining metal; being something like silver in its colour and appearance; tho not strictly referable to any of the metals, or other known bodies. This is the starry regulus of the philosophers, which some of them have esteemed as the basis of the grand secret. The adept, in their language, tell us to procure the mercury of antimony *per se*, "wherein if gold be put, it dies, and rises again the "glorious stone." But how to free antimony of all its sulphur, so that nothing but perfect mercury may remain, I frankly acknowledge my self ignorant: for tho I have purified it over and over again, yet it constantly remained brittle: nor could I ever render it malleable by mixing it with iron, copper, mercury, or any other metalline body. *M. Homberg*, however, tells us he knew the method of doing it; which must needs be a very valuable secret. The scoria cast off even in this fourth operation is more fiery, and apt to run in the air, but less emetic, than any of the former. And indeed the vomitive virtue of the scoria always decreases as the operation is repeated.

## PROCESS CLXXXVII.

### *Exhibiting the preparation of the* golden Sulphur *of* ANTIMONY.

*The process.* 1. *TAKE the scoria of antimony, cast off from the metalline part, in the preceding processes; boil it in fair water, and filtre the hot decoction, which will thus give the sulphur of the antimony, dissolved by the alkalizated nitre, in the form of a red and scentless lixivium. To this solution, add a sufficient proportion of distilled vinegar, or any other acid, and immediately the whole will coagulate, change to a brown colour, emit an intolerable stercoraceous odour, like that of human excrement, and precipitate a red powder. Then*

 *this*

*this whole coagulated mass, being washed by repeated affusions of fair water, till the liquor comes away as scentless and insipid as it was poured on, and afterwards gently dried, becomes a red powder, called the golden sulphur, or precipitate of antimony, either on account of its own colour, or the yellow one it gives to glass, metals, and other kinds of bodies.*

2. If the decoction of the scoria of antimony be permitted to stand a few hours, before the spirit of vinegar is poured thereto, it will almost wholly concrete into a very thick mass. And as soon as ever the vinegar is added, there ensues a most disagreeable scent, which may be avoided by placing the containing vessel under a chimney. *Observations thereon.*

3. To understand the reason and nature of this process, we must observe that the nitre, fused along with the antimony, turns alkaline in the fire, and therefore dissolves the sulphur; and thus makes it soluble also in water, leaving it precipitable with acids, which destroy the force of alkalies. *Its rationale.*

4. This precipitate, or golden sulphur of antimony is emetic, as well as the regulus of antimony, tho in a somewhat less degree; whence it appears, that the vomitive virtue of antimony is lodged as well in its sulphureous as its metalline part. Being given in the quantity of three or four grains, it either proves emetic, cathartic, diuretic, or sudorific, according as its force happens to be determined. *Virtues and uses of the production.*

## PROCESS CLXXXVIII.

### *Exhibiting the preparation of the* Crocus *or* Liver *of* ANTIMONY.

1. TAKE *equal quantities of antimony, purified by simple fusion and of good salt-petre; grind them to fine powder, mix them together, and cast of the mixture, by small parcels, into an ignited iron-ladle: the powder will at every time, flash and go off with a force like gun-powder; and by this means alone, when the last detonation is over, the matter will be turned to a dark, or shining liver-coloured substance, called by the name of* Crocus, *or* Hepar antimonii. *The process.*

2. This process should be performed in an iron-ladle, and by repeated injections of the powder, on account of the violence of the detonation, wherein it greatly resembles gun-powder, the ingredients whereof are nitre, sulphur, and coal; the two former of which are contained in the present mixture, the metal supplying the place of the other. *The cautions it requires.*

3. The crocus it self is most violently emetic, in a very small quantity; the tenth part of a grain being unsafe to venture upon for internal use; tho it has sometimes been employed in a larger dose. And in case it proves too strong, the best way to stop its vehemence, and prevent farther ill-effects, is to order warm vinegar, sweetened with sugar, to be drank in the quantity of three or four ounces. But it seems *Virtues and uses of the production.*

now

now to be in disuse; the *crocus metallorum*, as it is called, being given with much more safety. This *crocus metallorum* is no more than the liver of antimony it self, ground and well washed by repeated affusions of warm water, and dried to a powder again. It is also called *Crocus Antimonii*, *Terra sancta Rulandi*, *Terra aurea*, *Terra rubra*, &c. a single grain whereof, tho thus mitigated and edulcorated, will operate so violently, both by vomit and stool, that it is sometimes hard to stop it, or prevent dangerous consequences from its use: for which reason, it is commonly infused in wine, and the clear part of the infusion alone prescribed internally. One ounce of this edulcorated powder being put to thirty or forty times as much of any wine that is not too acid, and gently boiled with it in a tall glass, or let stand for four and twenty hours, the filtred liquor is accounted an excellent, pleasant, and tolerably safe emetic, given from two drams to as many ounces. And this was the great secret of *Rulandus*, who called it his golden tincture; but is now the common emetic wine of the shops; and which, it is vulgarly thought, does not lose of its virtue, if fresh wine be added to the fæces, or powder at the bottom of the containing vessel: but this is a great mistake; for the first parcel is always the strongest or most vomitive, and the succeeding ones gradually weaker; so that the third infusion will scarce operate at all. The powder, thoroughly edulcorated, or freed from its salt by being boiled in water, and with an equal quantity of sugar-candy, made into fine powder, is greatly commended for taking off all inequalities, films, specks, or pearls in the eyes; a small portion thereof being blown into them with a quill, twice or thrice a day. And this was the secret of a famous oculist at *Amsterdam*.

## PROCESS CLXXXIX.

### *Exhibiting the preparation of a mild Emetic from* ANTIMONY.

*The process.*

1. *TAKE of antimony, purified by fusion, one part, and of nitre two parts; reduce them to powder, mix them, and throw the mixture by degrees into an ignited iron crucible or ladle; upon which it will instantly flash and explode like gun-powder, and at last leave a greyish coloured mass, inclining to yellow, behind; which of it self, or being edulcorated by repeated affusions of water, becomes a mild and safe emetic.*

*Virtues and uses of the production.*

2. This preparation is a much more gentle emetic than the *crocus metallorum*, and may, for that purpose, be given from one grain to eight or ten; tho it will not always operate by vomit, especially in such as have been used to the sea, or whose bodies abound with acid; but sometimes takes downwards. And if somewhat more than two parts of nitre be, in like manner, added to two of antimony, the effect of the preparation will be of the same kind upon the body, tho much milder than the former, or equal to a smaller dose thereof; and being taken in the

the same dose, it will pass the stomach, and only excite a nausea, and perhaps a reaching, for a few hours, but rarely proceeds to a full vomit, unless the patient in his constitution be greatly inclined thereto. Hence, by stimulating the intestines, it proves an excellent medicine in all those distempers which require the first passages to be cleansed, or obstructions therein to be opened. It is, therefore, good in case of worms and phlegmy matter lodged in the *primæ viæ*; tho on account of the long continuance of the nausea it creates, it proves troublesome enough to the patient.

## PROCESS CXC.

### *Exhibiting the preparation of* diaphoretic ANTIMONY *with nitre.*

1. *TO one part of antimony, purified by fusion, and reduced to powder, add three parts of good nitre, and grind them well together in a stone-mortar; throw the mixture, at several times, into an ignited crucible, and it will fulminate like gun-powder, tho in a less degree than in the preceding processes; and being afterwards kept in fusion, for a quarter of an hour, it will turn into an almost white mass, called* Antimonium diaphoreticum nitratum, *or diaphoretic antimony with nitre; being destitute of an emetic virtue.* *The process.*

2. The powder ought not here to be thrown all at once into the crucible, because in that case some metalline part of it might happen not to be calcined; whence the medicine would become emetic, contrary to the design of the process. Nor ought the matter to be detained in the fire longer than a quarter of an hour; otherwise the antimony would turn to a regulus, and fall metalline to the bottom of the crucible. *Directions relating to it.*

3. This is the diaphoretic antimony that I constantly use in my practice; and it will not, I find, prove vomitive, tho given without being washed, in the quantity of a dram at once; but only operate by sweat. But *Basil Valentine*, who first described the medicine, imagined I know not what emetic virtue to adhere to the nitre; and therefore orders it to be frequently washed in water, to free it from its salt. But this is perfectly needless; for neither has nitre any vomitive faculty, nor does the diaphoretic antimony operate in that manner, tho used as it comes from the crucible, without any ablution. Yet the inventor, not content with ablution, orders it to be afterwards calcined, and then fixed with alkalized alcohol; as supposing that its emetic virtues were pinned down by such treatment: but this method would entirely destroy its action, and render it insignificant in the body. When prepared in the manner of the present process, the nitre and the sulphur of the antimony become a kind of *sal polychrestum*; the metalline regulus being at the same time *Virtues and uses of the preparation.*

reduced

reduced to a white calx; which, as well as the sulphureous part of the antimony, is deprived of its emetic property by the nitre in the operation: whence we see that the vomitive poison of antimony may be corrected by suitable quantities of nitre, and degrees of calcination, and the mixture thus be converted into almost all kinds of medicines. Thus antimony, calcined with an equal proportion of nitre, becomes a violent emetic and cathartic; with twice its quantity of the same, a mild emetic; with above twice its weight thereof, a stimulating purgative, that operates upon the stomach so far as to give a nausea; and with thrice its quantity of nitre, a kindly diaphoretic; which may be given in any dose from a grain to a dram. Ordered in the quantity of ten or twelve grains, four or five times a day, with any convenient liquor, it is an excellent medicine in the measles and small-pox, and prevents the too great suppuration of the pustules. And in all respects it seems to have perfectly the same virtues with *sal polychrestum*, and no other; for I could never observe it had those which *Sylvius* attributes thereto.

## PROCESS CXCI.

### *Exhibiting the preparation of the common diaphoretic* ANTIMONY, *or* Antimonium diaphoreticum dulce.

*The process.*

1. REDUCE *the diaphoretic antimony of the preceding process to impalpable powder; boil it in fair water; filtre the decoction, and a white powder will be left in the filtre; which being well washed by repeated affusions of fresh water, and gently dried, is the dulcified, or common diaphoretic antimony of the shops.*

*Nature of the production.*

2. The powder thus obtained, is a mere metalline calx of antimony, reducible to a regulus by the fire, and entirely destitute of all medicinal virtues, or serving only to load, oppress or choak up the body by its inactivity and weight *. That this is fact, I have found by many experiments; and knew a noble lady, who was, by the frequent use thereof, thrown into a languid state, with pains in the stomach, of which she afterwards died. When the body came to be opened, her stomach and intestines were found crusted over, or lined on the inside, as it were with potters-clay, by this powder sticking and being there inviscated by the native mucus of the parts. Yet some there are, who persuade them-

* It happens unluckily in medicine, that what some physicians positively assert, others as positively deny; and both from what is commonly appealed to as decisive, experience. *Antimonium diaphoreticum* is by many celebrated physicians expresly declared medicinal, and by one in particular of singular efficacy in delirious cases. *Ad delirium*, says he, *maximè prodest* Antimonium diaphoreticum, *per se sumptum: quod licet à quibusdam medicis ut effœta calx æstimetur, sæpè tamen, & semper per se, optato successu, non modo in vigiliis, sed & in delirio præscripsi.* And again, *Antimonium diaphoreticum, cujus efficaciam tum ad pustulas expellendas, tum ad sedanda deliria sæpe expertus sum.*

selves

selves that this preparation has wonderful virtues, and, like a magnet, attracts to it self all that malignity, or poison of an antimonial nature, which shall at any time be lodged in the body; the like whereto, they imagine was contained in the antimony it self, before it underwent this operation; but that it is thereby perfectly devested and freed from it. And hence *Tachenius* recommends it as an admirable anti-pestilential remedy. This notion seems to have sprung in the minds of some chemists, from the property which antimony has of purifying metals; after which manner, they fondly conceited it would also purify the blood: tho, to do the former, it requires to be fused in a violent fire.

## PROCESS CXCII.

### *Exhibiting the preparation of* Nitrum Antimoniatum, *or the diaphoretic Nitre of* ANTIMONY.

1. *EXHALE the strong decoction, or filtred solution, of the preceding process, over a gentle fire, to dryness; and there will be left behind a salt, like the* sal polychrestum, *composed of nitre and the sulphur of the antimony, called* nitrum antimoniatum. *The process.*

2. If the decoction be here made strong, and filtred hot, it will dissolve and contain all the nitre that was united to, and fixed the diaphoretic antimony, and absorbed the sulphur; whence the salt obtained by the exhalation of the superfluous moisture, must needs be a kind of *sal prunellæ*, or *sal polychrestum*. And accordingly it is aperitive, cooling, diuretic, and diaphoretic; whence it becomes useful in inflammatory fevers, the small-pox, measles, *&c.* and capable of opening obstructions without stimulating or fretting the parts. To answer these ends, it may be given in the quantity of a dram, with very great safety and success. The solution or lixivium it self, may also be taken to advantage, and will perform all that can be expected from the diaphoretic antimony prepared with nitre, without at all oppressing the body by its weight like that; which is owing to the metalline part it contains. When, therefore, the chemists throw away this lixivium, in the preparation of the common diaphoretic antimony, they throw away an admirable medicine, and save a very bad one. *Nature and Virtues of the production.*

## PROCESS CXCIII.

### *Exhibiting the fix'd Sulphur of* ANTIMONY.

*The process.* 1. TO *the strong and clear lixivium of the preceding process, pour a sufficient quantity of good distill'd vinegar, to make a thorow precipitation; upon which, the liquor will immediately become turbid and milky, and let fall a fine, copious, white powder, or precipitate, to the bottom of the containing vessel. This powder being, by the filtre, separated from the liquor, well wash'd by repeated affusions of fair water, and gently dried, is* Tachenius's *fix'd, anti-pestilential sulphur of antimony.*

*Chemical rationale thereof.* 2. The nature and reason of the operation will appear from remembring that antimony contains sulphur; that nitre is in the fire convertible into fix'd alkali, by any inflammable body; and that fix'd alkalies are solvents of sulphur, which is afterwards precipitable by acids.

*Nature of the productions.* 3. The turbid liquor of this process is call'd the milk of antimony; and is said to be an excellent medicine in case of poisons, and all diseases proceeding from them. It is certainly possess'd of an alexipharmic virtue, on account of the Vinegar, and nitre, both which are good medicines in acute and pestilential cases, and here unite with the sulphur into a *sal polychrestum*. For the same reason the liquor that passes the filtre is also of great medicinal virtues; being wonderfully aperitive, and good in all hot, acute and malignant diseases; and the better for being discharg'd of that indolent white powder or precipitate; for the fix'd sulphur it self is only the most sluggish and unactive part of the sulphur, precipitated by the vinegar, along with the metalline calx of the antimony, that was join'd to the nitre; and consequently has no considerable virtues as a medicine. I have given it in large quantities, but cou'd never find any good effect it produc'd: yet *Tachenius* extols it as a noble remedy against the plague; but he was certainly mistaken, and unjustly ascrib'd the good effects he saw it have in that distemper to this sulphur, which in reality were owing to the vinegar he gave along with it; which indeed is an admirable anti-pestilential remedy. In effect, this preparation ought of it self to be esteem'd no more than an indolent precipitate, or calx, as I have found by a large number of experiments.

## PROCESS CXCIV.

### *Exhibiting the preparation of the Butter, or icy Oil of* ANTIMONY.

*The process.* 1. TAKE *equal parts of common, crude antimony, not too much purified, and of new and shining* Venetian *corrosive sublimate; grind them separately to fine powder, in a glass mortar, set in a dry cool place, and afterwards*

*mix them well together, for a considerable time, with great care that none of the noxious dust gets up the nostrils, or enters thro' the mouth into the lungs; then cautiously put this powder into a large coated retort, capable of containing four or five times the quantity, so cut as to leave a very large aperture, and the remaining part of the neck extended somewhat long and strait; lute on a very large receiver, and distil in a sand-furnace, with due degrees of fire. A gentle heat, being continued for the first hour, will bring over a small quantity of a sharp, thin, pellucid caustic water; when the fire is a little increased, there rises a white oily liquor, which afterwards congeals to a thick unctuous substance, called the icy oil, or butter of antimony, and often adheres to the neck of the retort; where, if it be detain'd, it ought to be melted down into the receiver by the application of live coals near that part of glass where it lodges: when by gradually raising the fire, this butter is all come over, and red or dark-colour'd fumes appear, the receiver must be changed, for fear of fouling what has already ascended, and now, in the cold, appears like ice, but melts by heat into a kind of oil. Then increase the fire to its greatest degree, and add likewise a fire of suppression; continue thus, for two or three hours, till the retort is almost red hot; by which means volatile red fumes will first ascend, which are carefully to be avoided; then there will be made to sublime, a variously colour'd matter, sticking to the neck of the retort; some globules of quick-silver passing into the receiver. When the vessels are cold, break the retort, and an imperfect cinnabar of antimony will be found in the neck; which tho it may seem black, almost like æthiops, will, when pulverized, appear of a reddish colour; and at the bottom a small quantity of antimony; all the butter having pass'd into the receiver.*

2. This process should only be perform'd with small quantities of the ingredients, to prevent the mischief which might otherwise arise in case of an accident; as the blocking up of the neck of the retort by the butter. The antimony and sublimate are by all means to be mix'd and ground in a glass mortar; for they would corrode one of iron or brass, and thence make a kind of butter in the trituration; during which the effluvia must cautiously be avoided, otherwise grievous vomitings, a salivation, and the worst of symptoms will arise in the body; nay, these efluvia are capable of affecting the brain and lungs to such a degree, as to render a man for ever languid, and unfit for the offices of life. The retort likewise must by all means have a very large aperture; because it frequently happens that the butter ascends all at once, choaking up the neck of the glass, and causing it to burst with great violence; to which accident a very famous chemist of this university ow'd his death: for the corrosive vapours being by this means instantly dispers'd thro' the air, they at once constringe the lungs, and either bring on an incurable peripneumonia, or prove suddenly mortal. The quantity of cinnabar obtain'd in the process, will constantly be proportionable to the degree of impurity in the antimony; for if the regulus of antimony were here used instead of antimony it self, scarce any cinnabar at all would be obtain'd; this always proceeding from the sulphureous part of the mineral, join'd with the mercury of the corrosive sublimate. *The caution it requires.*

*Its doctrine and use.* 3. We are here taught a general method of rendring metallic bodies volatile, or reducing them to the form of a butter: for the acid spirit of the sea-salt contain'd in the corrosive sublimate, acts strongly upon, and dissolves their metalline parts; whilst their sulphur, now united to the revived mercury, is converted first into an æthiops, then into a cinnabar; leaving the regulus of the metal, changed and volatilized by the acid, to be carry'd over into the receiver by the force of the fire: for the butter of antimony is nothing more than the regulus of that semi-metal alter'd in its nature and form by the sublimate. And hence antimony, which of it self is tolerably fix'd in the fire, may be render'd exceedingly volatile; for if this butter be again committed to distillation, it will rise as easily as spirit of wine. But this process does not only hold true in antimony; it is really universal with regard to metals. Gold it self, which is said to lose nothing of its weight tho detain'd for a month in a glass-house furnace, may thus be render'd volatile, by distilling it with an equal quantity of the regulus of antimony, and twice as much corrosive sublimate. And in the same manner there may be made a strange kind of butter with copper. So likewise with one part of tin, and two parts of mercury-sublimate, there will arise in distillation that strange suffocating, perpetually fuming, and exceedingly corrosive liquor mention'd by Mr. *Boyle*.

*Nature and use of the production.* 4. This butter of antimony is a violent poison, used internally; for it presently burns and corrodes all the parts it touches: on which account 'tis employ'd as a caustic by the chirurgeons: and I know no other use of it in medicine; tho some imprudently venture to prescribe it internally. And in like manner, the butter of any other metal, prepar'd in this manner is violently corrosive.

## PROCESS CXCV.

### *Exhibiting the conversion of the Butter of* ANTIMONY *into Oil.*

*The process.* 1. W*ARM the butter of antimony of the preceding process at a gentle fire, taking care to avoid the fumes it affords, and it will melt and run like oil; whilst it remains in this state, pour it into a clean glass retort, and with a gentle heat in sand, and the like apparatus and caution as before, distil it to dryness. The matter that comes over, will be much more volatile and liquid than in the foregoing process; tho still assuming an icy form in the cold; whence it is called rectify'd butter of antimony; but if it be distill'd or rectify'd again in the same manner, it will turn to a perfectly transparent fluid, and exceeding corrosive oil.*

*The caution to be observ'd therein.* 2. The vapour at any time ascending from the butter of antimony in this process, is to be avoided with the utmost caution; being so highly poisonous, as, if taken in at the nose or mouth, to prove instantly mortal.

3. The oftner this oil is distill'd over, the more fluid, subtile and volatile it always becomes; from whence we learn the surprizing power that salts have of changing metalline bodies, and totally converting them from their inactive, harmless, fix'd and solid nature, into most subtle, volatile, and violently poisonous fluids. *The doctrine it affords.*

4. This oil is chiefly used by chirurgeons, as a caustic, to take off warts, small cancers, schirrous tumours, *&c.* which it does after the manner of *Lapis infernalis*; tho at the same time it causes a greater inflammation than that. When digested with about thrice its own weight of alcohol, it makes the purple tincture of antimony; which was the secret of the excellent Mr. *Boyle*, and highly valued in *England*, and by him communicated to the admiral *du Quesne*; a single drop or two whereof being taken in any convenient vehicle, works well by vomit. *Virtues and uses of the production.*

## PROCESS CXCVI.

### *Exhibiting the precipitation of Butter of* ANTIMONY *into* Mercurius Vitæ.

1. *POUR a sufficient quantity of warm rain water upon butter of antimony, and it will all immediately precipitate into an exceeding white and ponderous powder; which being, by the filtre, separated from the liquor, and well wash'd by repeated affusions of warm water till it becomes insipid, and then gently dried, it becomes what is improperly called* Mercurius Vitæ; *being in reality no more than a fine calx of antimony, without any mercury at all.* *The process.*

2. This antimonial powder, otherwise call'd algarot, remains fix'd in a pretty strong fire, but is wholly reducible by a greater into regulus of antimony; which shews its metalline nature. And the reason of the process seems to be this; that the acid spirit of the sea-salt contain'd in the mercury-sublimate, having been set loose from the mercury it before dissolved, fastens upon the regulus of antimony, and turns it to a butter; when, the menstruum being weaken'd with water, the regulus can no longer remain suspended in the liquor, but falls, in the form of a powder, to the bottom. Whence we see, that by means of water alone, a solid, ponderous, and fix'd body may be instantaneously procur'd out of a fine, volatile fluid. *Nature of the production; with the rationale and doctrine of the process.*

3. The water here first poured upon the butter of antimony, when filtred, is an excellent menstruum, or spirit of sea-salt, tho improperly called the philosophic spirit of vitriol, and capable of dissolving gold into *aurum potabile*; for it contains the strong acid spirit of the sea-salt that enter'd the composition of the mercury-sublimate: which, however, is here wonderfully changed in its nature, by mixing with the quick-silver; so that scarce any known menstruum can, for power, be compared therewith; as performing those strange things which the illustrious *Boyle* relates of his

*menstruum*

*menstruum peracutum*; especially when evaporated to about a fourth part of its original quantity.

*Virtues and uses of the productions.* 4. The edulcorated precipitate it self is violently emetic, in the quantity of two or three grains; but may be depriv'd of that virtue by calcination. The filtred solution, however, is not vomitive, but may succesfully be used internally as a good spirit of salt; for it seems to have all the virtues thereof.

## PROCESS CXCVII.

### *Exhibiting the preparation of* Bezoar Mineral *from Butter of* ANTIMONY.

*The process.* 1. *To a quantity of rectify'd butter of antimony, contain'd in a glass vessel, gradully drop of spirit of nitre till the effervescence they make together entirely ceases, and there will a perfect dissolution be made: then dry the matter by a gentle fire, and again pour spirit of nitre to the remainder; dry it, and repeat the operation one time more: afterwards put the remaining powder into a crucible, and set it in a strong open fire till it becomes almost red hot; detain it in this state for half an hour, and what remains will be a white ponderous powder, call'd bezoar mineral* *.

*Its rationale, and uses.* 2. In this process we are to conceive that the metalline part of the antimony, dissolved and brought to a butter by the spirit of salt in the mercury-sublimate, becomes an *Aqua regia* by the affusion of spirit of nitre, which thorowly dissolves the regulus of antimony with a great effervescence; but when the acid is here driven away by the violence of the fire, nothing remains behind but the sluggish and calcined metalline part of the antimony; which tho dignified with the name of mineral bezoar by *Basil Valentine*, is destitute of all medicinal virtues, and only serves to oppress the body by its gravity; being perfectly indigestible therein. And in this it somewhat agrees with the bezoar-stone, whence it seems to have borrow'd its name. *Sylvius*, upon the authority of *Basil Valentine*, the first inventor of this preparation, ventur'd to introduce it into medicine; and frequently gave it with very bad success. Yet many are to this day persuaded, with him, that it is possess'd of wonderful antidotal virtues; as being obtain'd innocent and harmless from that violent poison, butter of antimony; whence they conclude it must needs have a magnetical power of attracting to it self, like the bezoar-stone, all the poison that happens to be lodg'd in the body: but tho, in reality, it has no medicinal virtue at all, yet it affords us an admirable experiment for solving chemical phænomena, and discovering the nature of fossils. Some there are, indeed, who imagine it to be emetic; and so it is when

* Spirit of nitre several times drawn off from the butter of antimony, as it may be in this process, is the *menstruum peracutum* of Mr. *Boyle*.

not

not well prepar'd; but not otherwise. The experiment shews that acids may make a violent ebullition with acids, as well as with alkalies, and undergo surprizing changes thereby; for butter of antimony and spirit of nitre are both violent acids. And if the preparation it self be press'd with a violent fire, it will afford the purest regulus of antimony that can any way be procured.

## PROCESS CXCVIII.

### *Exhibiting the preparation of* Cinnabar *of* ANTIMONY.

1. GRIND *to fine powder the imperfect cinnabar which rises in the distillation of butter of antimony, according to the hundred and ninety fourth process, and sublime it a second time, with proper degrees of fire, in a new coated retort, till the bottom thereof be almost of a red heat: the cinnabar will now rise in the neck of the glass much purer than before; and when ground will appear of a beautiful red colour, like minium.* *The process.*

2. The chemical rationale of the process is this. Corrosive-sublimate being no more than the acid spirit of sea-salt joined to the body of quick-silver; and sulphur abounding with a coarse external sulphur, not to be touched by acids; the metalline part of the antimony is here dissolved, like gold in *Aqua regia* or spirit of sea-salt; upon which, the quick-silver is again set loose or revived, as being depriv'd of the acid that before held it dissolved; so that the sulphur of the antimony readily lays hold thereof, and, by means of the heat, converts it into æthiops mineral, which becomes cinnabar by sublimation: from whence the fluid mercury may again be recover'd pure, by grinding it well, and distilling it, with twice its quantity of fix'd alkali, or iron, which dissolves and strongly absorbs the body of the sulphur. *Its chemical rationale.*

3. Whether this cinnabar of antimony be possessed of those virtues ascribed to it by *Helmont*, I have not experienc'd; but it seems probable to me that it will constantly produce the same effects with common factitious cinnabar; as being produced in the same manner with that. *Virtues of the production.*

## PROCESS CXCIX.

### *Exhibiting the preparation of the Emetic* Flowers *of* ANTIMONY.

*The process.* 1. TAKE *of antimony dissolved, and render'd corrosive by* Aqua regia, *and exhale it over a gentle fire till it is perfectly dry; then reduce it to fine powder, and grind it well with an equal quantity of pure sal ammoniac; put the mixture into a very wide-mouth'd and capacious, but low glass cucurbit, to which fit a very large perforated head; lute it on well, and bury the cucurbit up to its neck in sand; then light up the fire, and increase it by degrees: what comes over first will be an aqueous acid liquor; after this, white fumes will arise; when these appear, take away the receiver, lightly cover the nose of the glass-head with paper, and raise the fire, which will cause the antimony to sublime, and fix it self to the top of the glass in various colours; leaving only a small quantity of fæces of the nature of sea-salt, behind. When the glasses are cold, take out the variously colour'd matter in the head, and preserve it under the name of emetic flowers of antimony.*

*The caution it requires.* 2. The orifice of the head ought not to be closed in this operation before the white fumes ascend, because the vessels might otherwise break. Almost the whole body of the antimony is here sublimed into what, on account of its many colours, is called the flowers thereof; tho it also happens to resemble flowers in its figure.

*The doctrine it affords.* 3. This process shews us the art of what the chemists call killing and reviving; among whom killing is the same as fixing, or corroding; and reviving the same as subliming, or opening the bodies of things. We are also hence taught a method of subliming, or opening the bodies of metals, and of producing various colours by thus unlocking the texture of one black body; which when treated with a violent fire, becomes of a red colour; but if urged with a strong one, turns of a brown; antimony thus seeming to have the character of the philosophical mercury.

*Medicinal virtue of the production.* 4. These flowers of antimony prove strongly emetic, in the dose of a single grain; and if wash'd and edulcorated with warm water, so as to become perfectly insipid, and appear either grey or brown, they still retain this property; and are then called *Helmont*'s emetic flowers of antimony.

PRO-

## PROCESS CC.

### *Exhibiting the preparation of* Helmont's Antimonium diaphoreticum, *or the fix'd* Flowers *of* ANTIMONY.

1. T*AKE one part of the dulcified flowers of antimony, prepared after the manner of the preceding process, and three parts of pure, dry nitre; grind them well together; and throw the mixture, by degrees, into an ignited crucible, and it will fulminate like common diaphoretic antimony with nitre, but less strongly; and thus turn to what is called fix'd flowers of antimony; which being well wash'd in several waters, ground fine, and twice or thrice deflagrated with alcohol of wine, makes the* Antimonium diaphoreticum Helmontii, *that has no manner of emetic virtue.* *The process.*

2. These fix'd flowers of antimony are apt to prove vomitive, unless they be well dulcified, or several times well wash'd with water; especially in such constitutions as are easily moved that way: but if taken in the quantity of two scruples, or even a dram, along with vinegar or other small acid, they only prove sudorific. *Helmont* gave this preparation the name of *antimonium diaphoreticum*, who is large upon its virtues; and in particular recommends it for the cure of all tertian and quartan agues: but I could never, upon repeated trials, find it answer the character he gives it. Being given in the dose of fifteen or twenty grains, along with any emetic, sudorific, purgative, or diuretic, it will have its force and virtue determin'd by them, and operate successfully enough. And thus it may do service in distempers whose cause is seated in the second stage of circulation, and be made to purge and purify the blood; as also to cure agues, when the cause thereof is not fix'd, but movable. *Nature and virtues of the production.*

## PROCESS CCI.

### *Exhibiting the preparation of* Helmont's purging Flowers of ANTIMONY.

1. T*AKE six parts of* Helmont's *diaphoretic antimony, well wash'd from its adhering nitre, rosin of scammony three parts, and cream of tartar one part; grind them together to a fine powder, which is called the* purging flowers of antimony.

2. This preparation differs but little from the *Pulvis Comitissæ Warwicensis*, or *Cornachini*; *Helmont*'s diaphoretic antimony here, supplying the place of the common in the other. This is however an excellent cathartic in all dropsical cases, and such distempers as are curable by purging. Being given from eight or ten grains, to thirty or forty, three hours before the paroxysm of an intermitting fever, it seldom fails to cure it at the first *Medicinal virtues and uses of the production.*

 taking;

taking; it likewiſe commonly cures quartans at the ſecond or third: and this I have found true by repeated experiments. But when the fever proceeds from ſome internal diſorder of the parts, as a ſchirrous or cancerous tumor, or the like; this medicine is of no efficacy at all. In other caſes, it ſeldom fails above one time in ſix: and with this proceſs we end the whole chain *.

* This chain of proceſſes upon antimony deſerves the utmoſt attention and regard of thoſe who deal in mines, or deſire to examine metalline ores. They preſent us, in effect, with the beſt methods of purifying metals, and bringing them to the teſt, or making eſſays thereof; and will, with the diſcerning chemiſt, paſs for more than the diligent M. *Lemery*'s laborious treatiſe wrote expreſly upon the ſubject of antimony; for here, as in all the other parts of this noble work, our author had a view to make his proceſſes as univerſal as poſſible; that is, to make them ſerve for general examples in the chemical treatment of all the bodies of the ſame rank or claſs with that under conſideration; whence this hiſtory of ſemi-metals, well underſtood, will inſtruct any one to treat foſſils, or metalline ores, to as much advantage, as the chain of general proceſſes perform'd upon animals or vegetables, will inſtruct him chemically to examine all the ſubjects of the animal or vegetable kingdom.

THE

# THE DOCTRINE

Of the preceding Chain of

# PROCESSES,

Drawn out to exhibit the

## Chemical Hiſtory of the particular QUALITIES of Natural Bodies.

*Introduction to the chemical hiſtory of particular qualities.*

WE have now methodically gone thro'that ſeries of proceſſes which ſeems to us ſufficient fully to inſtruct anyone in the whole art of chemiſtry; for tho we have not directly exhibited the production of all that infinite number of medicines, or ſhewn all the chemical reſolutions, compoſitions, *&c.* which have, and might ſtill be for ever invented and diſcover'd by freſh combinations, and working upon all the various particular materials wherewith nature ſupplies us; yet have we laid the foundation for all ſuch proceſſes as are performable upon natural bodies; and ſhewn the general methods of performing them, according to the ſtrict rules of art, by a variety of ſtandard examples, which together make the elements of chemiſtry, or a regular ſyſtem of general proceſſes upon the productions of the vegetable, animal, and foſſil kingdoms; which compleats the third and laſt part of our labour. Nothing remains farther to be done, but by way of corollary from this third part, to draw out the doctrine it contains, with regard to thoſe remarkable

qualities, or phænomena of bodies, *Solution*, *Coagulation*, *Precipitation*, *Effervescence* or *Acid* and *Alkali*, *Odours*, *Tastes*, *and Colours*; which making a considerable part of natural philosophy, it will be of considerable use to understand how they are produced.

## CHEMICAL HISTORY *of* SOLUTION.

*Solution, by what means effected.*

SOLUTION, according to all instances of it afforded us in the preceding series of processes, is performable, (1.) By *water*; which, as we have seen, dissolves bodies by dilution, maceration, infusion, coction, distillation, fermentation and putrefaction. (2.) By *oils*; which act only by dilution, infusion, coction, and distillation; and not, like water, by fermentation and putrefaction. (3.) By *fire*; which dissolves bodies by torrefaction, ignition, calcination, fusion and sublimation. (4.) By *inflammable* spirits; which act by dilution, infusion, coction, and distillation. (5.) By *fixed alkaline salts*; which act at the fire by torrefaction, ignition, calcination, and fusion; but together with water, or *per deliquium*, by dilution, maceration, infusion and coction; but not by distillation. (6.) By *volatile alkaline salts*; which, when used dry, act by sublimation; but when diluted, by maceration, digestion, coction, and distillation. (7.) By the more *fixed acid salts*, as oil of vitriol, *&c.* which act by dilution, digestion, decoction, and distillation. (8.) By *acid volatile salts*; which act by dilution, digestion, and distillation; but not by fermentation and putrefaction. (9.) By *compound and saponaceous salts*, whether acid or alkaline, fixed or volatile; which act according to their respective natures. (10.) Lastly, *Solution* is performed by metalline bodies; and that by means either of amalgamation with mercury, or fusion; for metals in fusion penetrate and dissolve one another. And these are the several means whereby the *Solution* of all bodies is effected.

## CHEMICAL HISTORY *of* COAGULATION.

*Coagulation, by what means producible.*

1. COAGULATION, or the change of a liquid into a solid body, we have seen is performable by *water*; and (1.) upon *salts*, by turning them into crystals: for when any kind of salt, whether acid or alkaline, is dissolved in water, and the solution evaporated to a pellicle, it appears crystalline; the water rendring the salt transparent; and leaving it opake, as soon as by any means it is driven away. (2.) Upon *sulphur*; as in the golden sulphur of antimony. (3.) Upon *metals*, as in the vitriol of iron; to which it here gives transparency, as in the case of salts. (4.) Lastly, upon *earth*, whereto it gives a solid form; as in the making of tests, bricks, pots, *&c.* which would never hold together unless cemented with water. 2. Coagulation is also performable by *oils*, with salts, sulphur, and metals, the first whereof they turn into soaps, the second into balsams, and the third into plaisters. Thus ce-

ruse

ruse or minium, being boiled with oil, is thereby turned into a strongly coagulated matter, or solid mass. 3. Coagulation may be effected by *inflammable spirits*, with volatile, alkaline salts, as in the *Offa alba Helmontiana*; with the white of eggs, and serum of the blood, into a horny glebe; and lastly, with oil of vitriol, into solid sulphur or bitumen. 4. A fourth kind of coagulation is produced by the admixture of acids and alkalies; as in regenerated tartar, and *tartarum vitriolatum*, where the oil of tartar *per deliquium* is coagulated by oil of vitriol, and spirit of vinegar. 5. Fixed alkalies will likewise effect a coagulation; as milk, we saw, was coagulated by oil of tartar. 6. Acids also will do the same; thus the animal fluids are readily coagulated by oil of vitriol, &c. whence it is manifest, that coagulation is not the sole effect of acids or alkalies, as some have imagined. And besides these, there are other particular kinds of coagulation; as that of water, *sal mirabile Glauberi*, butter of antimony, &c.

## CHEMICAL HISTORY *of* PRECIPITATION.

*Precipitation, what.*

BY *precipitation* we understand the recovery of any solid matter, dissolved into a liquid form, or its reduction to a solid again, by the addition of some other body.

*By what means effected.*

This precipitation is effected, 1. By water, in all solutions of oil, and resinous bodies with alcohol. 2. By acids upon acids; as in the solution of metals. Thus a solution of silver in *Aqua fortis* will be precipitated by the affusion of spirit of salt, or oil of vitriol. And this shews the common opinion to be false, which supposes that acids can only be precipitated by alkalies. 3. A third kind of precipitation is of metals dissolved in acid menstruums by metals. Thus if a plate of copper be suspended in a solution of silver, made in *Aqua forits*, and diluted with water, the copper attracting the acid stronger than the silver, which cannot enter the pores thereof; the silver adheres to the surface of the plate, in form of a blackish powder, which is afterwards precipitated to the bottom of the vessel: in the mean time the copper dissolves, and turns the menstruum blue. Now suspend a plate of iron therein, and this will be dissolved, and the copper precipitated as the silver was before; and by adding *lapis calaminaris*, the iron likewise may in its turn be precipitated, and so also may the calamine, by the addition of salt of tartar, which will thus be dissolved in its stead; all in proportion to the quantity of precipitate let fall. And this is the method, constantly practised by the refiners, of obtaining their metals pure out of the solutions they make thereof: and these phænomena have confirmed many in their opinion of the possibility of the transmutation of metals; the acid menstruum thus transforming or accomodating it self to all the kinds thereof. And there is a vitriolic mine in *Hungary*, where metals are in this manner naturally precipitated.

Whence

Whence we learn, that ſuch precipitations may be effected without the mixture of acids and alkalies; tho alkaline ſolutions are indeed commonly precipitated by acids, and a ſolution of ſea-ſalt or vitriol by oil of tartar *per deliquium.*

## CHEMICAL HISTORY *of* EFFERVESCENCE; *or the Doctrine of* Alkali *and* Acid.

*Effervescence, what.*

1. EFFERVESCENCE, in the chemical ſenſe, ſignifies that violent inteſtine commotion which is immediately produced by mixing two bodies together, that lay at reſt before. This commotion is uſually attended with heat, frothing, a hiſſing noiſe, and a manifeſt ebullition; and is principally obſerved in fluids. To deliver the hiſtory of this phænomenon to advantage, we muſt conſider it in four ſeveral claſſes of bodies; and lay down ſo many different rules with regard to the thing it ſelf. The firſt claſs contains the manifeſt acids, as they are called, *viz.* vinegar, and its ſpirit, the juice of citrons, oranges, *&c.* ſpirit of nitre, ſpirit of alum, ſpirit of vitriol, ſpirit of ſulphur *per campanam,* ſpirit of ſea-ſalt, *&c.* The ſecond contains the artificial alkalies obtained either from vegetables or animals, by diſtillation, putrefaction, elixation and calcination; as ſpirit of urine, ſpirit of harts-horn, ſalt of tartar, *&c.* The third claſs contains all thoſe called terreſtrial alkalies or abſorbents; as the various kinds of ſhells, coral, chalk, bole, crabs-eyes, *&c.* And under the fourth and laſt come all the metals, and ſemi-metals; as gold, ſilver, lead, copper, tin, iron, quick-ſilver, antimony, zink, *lapis calaminaris,* &c. The effervеſcible bodies being thus diſtributed into claſſes, we come to give the rules which ſhew in what manner they may be made to exhibit their phænomena. And (1.) The ſubjects of the firſt claſs, being any of them mixed with thoſe of the ſecond, will always make a violent effervеſcence. (2.) In like manner, if any of thoſe of the firſt claſs, are added to any of the third, they conſtantly exhibit the ſame phænomenon. (3.) Again, the ſubjects of the firſt and fourth claſs will alſo make an effervеſcence together: but this rule is not univerſal; for ſome of them will not conſtantly do it, tho others will. It is here remarkable, that coral, crabs-eyes, or other teſtaceous bodies, being put entire to any manifeſt acid liquors, as thoſe of the firſt claſs, will, in the effervеſcence, be made to move or creep like living creatures; air, in the form of bubbles, continually breaking out from them. (4.) The objects of the third claſs differ widely from thoſe of the ſecond; and indeed agree with them but in one thing only; and that is in being effervеſcible with acids. The one is a claſs of fixed, ſcentleſs, inſipid, mild, aſtringent foſſil bodies; the other a ſet of ſuch as are volatile, odorous, ſapid, cauſtic, aperitive, and obtained by art.

*In what claſſes of bodies it obtains.*

*How producible therein.*

2. Hence we may fairly conclude, that mere effervefcence with acids is not of it felf fufficient to determine the nature of an alkali; and that fuch a name, which properly denotes a cauftic, fiery fubftance, fhould not be affixed to any mild and gentle body, fuch as chalk, bole, coral, &c. only becaufe it is effervefcible with acids. The nature of acid and alkalies cannot, therefore, poffibly be learnt by their effervefcence, but requires a joint knowledge of their other properties alfo; as particularly their tafte, manner of procuring, and the change of colour they produce in bodies *. *Ufe of the doctrine.*

3. There are three very remarkable kinds of effervefcence; *viz.* the violently cold, the violently hot, and the fiery or fuffocative. *Three kinds of effervefcence,*

If fal-ammoniac, or any pure volatile alkaline falt, be diffolved in water, and mixed with the manifeft acids, a violent ebullition, with a great degree of coldnefs, will enfue; fo as immediately to make the thermometer fink confiderably. This feems a paradox in philofophy, that coldnefs fhould be produced upon a violent agitation of the parts of bodies; the reafon whereof is not well underftood, tho the fact be certain †. *Viz. the cold,*

4. If to one part of *Glauber's* ftrong fpirit of nitre, contained in a large glafs veffel, there be gradually poured two parts of pure alcohol, prepared without the affiftance of an alkali; a great effervefcence will inftantly be produced, with a confiderable degree of heat. In which experiment, it is plain that the effervefcence cannot be owing to any alkali, becaufe there is none concerned. Nor can the like pretence be made as to the violent effervefcence caufed in the diffolution of iron by the fame fpirit of nitre; that metal containing a large proportion of fulphur, which abounds in acid, and affording no figns of an alkali. *The violently hot,*

5. The fiery, explofive, or ignivomous effervefcence, is made by fuddenly pouring one part of the effential oil of cloves to two of *Glauber's* fpirit of nitre, made very ftrong and good; for at the very inftant that they mix, a moft prodigious effervefcence, with a great eruption of flame and fuffocating fume, enfues; as alfo an effect equal to that of gun-powder: fo that it is very dangerous to make the experiment with any large quantity of ingredients, or otherwife than under a chimney; with great care to avoid admitting the noxious fumes at the nofe, or receiving the fudden light with the open eyes. This experiment fucceeds as well *in vacuo*, as in the free air; but never with alkaline falts. To make it fatisfactorily, and without danger, the fpirit of nitre *And the fiery.*

* The proceffes performed upon certain fubjects of the animal kingdom, as a criterion of their acid, alkaline, or neutral nature, were therefore accommodated rather to the popular notion, than ftrict philofophical truth. But as all other experiments that can be made of the fame nature, give their atteftation, we may fafely enough acquiefce in them; and of this particular notice was all along taken in the obfervations fubjoined to each procefs.

† M. *Geoffrey* has fome curious experiments, and a new fyftem, relating to this fubject, in the Memoirs of the Royal Academy of Sciences, for the year 1700. And Mr. *Boyle* furnifhes us with numerous fundamental obfervations and experiments relating thereto.

may

may be a little weakened with water, and mixed with any of the other eleven oils mentioned, as fit for the purpoſe, in the philoſophical tranſactions of *London.* And this grand effervefcence ſhews a very deſtructive method of producing fire for the ſervice of war. If a proper urn, charged with theſe two liquors, were to be thrown into a ſhip, or other retreat of the enemy, it might prove much more fatal than bombs and cannons. And a like effervefcence might alſo be made with oil of vitriol and oil of turpentine; which ſhews us that the moſt violent fire, as well as effervefcence, is producible by the joint action of oil and acid. And hence ſulphur has its great inflammability; as conſiſting of an acid united to an oil. This alſo may ſerve to ſhew the reaſon of that ſtrange effervefcence obſervable upon mixing and grinding together the filings of iron and powdered ſulphur, and afterwards reducing them to a paſte with water; for if this paſte be put into a cloſe veſſel, there will, in a ſhort time, ariſe ſuch a violent effervefcence, as to burſt the veſſel with an incredible force, and black, ſuffocating fumes. And if a large quantity of ſuch a maſs of paſte were to be buried deep under ground, it would ſoon cauſe a violent earth-quake, and burſt out with a very great flame and ſtench. Which may ſerve, in ſome meaſure, to account for vulcano's, or the fiery eruptions of particular parts of the earth; tho it hitherto remains unexplained how ſuch materials ſhould thus ſpontaneouſly take fire.

## Chemical History *of* ODOURS.

*Odours, where ſeated in vegetables.*

1. VEGETABLES we have found are reſolvable into water, oil, ſalt, earth, and a preſiding ſpirit reſiding in their oil: but neither water, ſalt, nor earth, when rendered pure, have any ſcent at all; tho they all become odorous if they contain any portion of oil, or the preſiding or ſpecific ſpirit. Thus the diſtilled waters of vegetables ſmell ſtrong in proportion to the oil or ſpirit wherewith they are impregnated. The oil of vegetables therefore may, in the groſs, be eſteemed the chemical cauſe of their odour; or, to ſpeak more accurately, the ſpecific ſpirit reſiding in that oil; which may perhaps be a part of the oil it ſelf, ſo ſubtilized and attenuated as to become miſcible with water. Oil, therefore, in ſtrictneſs, is not the cauſe of the odour of vegetables, any farther than that by being of an inviſcating and tenacious nature, it ſerves to lodge and detain that ſubtile and impalpable ſubſtance, properly called ſpirit, which gives them their ſpecific and diſtinguiſhing ſcent and virtues. For any, the moſt odoriferous oil, as that of cinnamon, if expoſed to a gentle heat, preſently loſes its ſcent, without ſuffering any remarkable diminution of its weight. Hence it appears, that whatever cauſe can extricate the oil, or this ſubtile ſpirit, from vegetable bodies, will of conſequence render them ſcentleſs.

*How deſtroyed.*

2. Animal

2. Animals alſo we have ſeen, are reſolvable by chemiſtry into water, ſpirit, oil, ſalt, and earth; yet none of theſe, when pure, are poſſeſs'd of any odour, except the oil, or rather the ſubtile and inviſible ſpirit lodg'd therein; which alſo may readily be ſet free by heat; upon which the oil loſes both its ſpecific ſcent and virtue. And therefore any cauſe able to extricate this ſubtile ſpirit from its priſon, the viſcid oil, will take away all the odour of animal ſubſtances. *Where ſeated in animals.*

3. Our preceding proceſſes have likewiſe ſhewn us that foſſil bodies are reducible into water, ſpirit, ſalt, ſulphur, metal and earth; all which, ſo long as they remain at reſt, even ſulphur it ſelf, yields no manner of ſmell; but when it comes to be burnt, whereby its parts are put into motion, it then proves ſtrongly odorous. And thus even the metalline part of minerals aſſumes an odorous nature; as we have ſeen in the butter of antimony, which is a mere melted metal. In like manner ſea-ſalt, which of it ſelf has no ſcent at all, ſmells ſufficiently ſtrong when converted into ſpirit. Mercury alſo is perfectly inodorous, yet yields a ſtrong ſcent when it comes to be diſſolved in *Aqua fortis.* Hence it appears that all thoſe cauſes which can bring minerals into action, or give motion to their parts, are capable of making them odorous; tho of themſelves they are perfectly ſcentleſs. And according to their nature or ſpecific characters, together with the nature of the operation they undergo, the ſcents they afford are varied. We obſerv'd a ſtrong odour to be inſtantly produced from ſcentleſs bodies, when ſal-ammoniac was mix'd with quick-lime. In the preparation of the golden ſulphur of antimony, the ſcent of human dung was momentaneouſly produced from bodies that before were partly inodorous, and partly of a grateful acid odour. A ſtrong aromatic ſcent we alſo obſerv'd was cauſed by the mixture of pure alcohol, and ſpirit of nitre. And laſtly, a violent odour we have found may be inſtantaneouſly deſtroy'd, by pouring ſpirit of nitre to any ſtrong alkaline urinous ſpirit. *In foſſils.*

## CHEMICAL HISTORY *of* TASTES.

1. THE prefectly pure water, oil, ſalt and earth, both of vegetables and animals, have no particular taſte, any more than odour, ſufficient to diſtinguiſh the principles of one ſubject from thoſe of another. Salts and oils have the greateſt pretence to it; yet the pure and perfect ſalt of liquoriſe cannot be known from the ſalt of wormwood: and if the operation be duly perform'd the caſe is univerſal. In like manner the ſtrongeſt and moſt ſapid vegetable or animal oil, by being expos'd to the free air, utterly loſes all its taſte as well as ſmell; and what remains thereof is not to be diſtinguiſh'd from oil of olives, oil of almonds, or any other pure and perfect oil. Whence we muſt conclude, that as oil alone conveys the ſpecific taſte of vegetable and animal ſubſtance, there muſt be ſome fine, ſharp, ſubtile thing, or ſpirit reſiding therein, which when the *Taſtes, whence in vegetable and animal ſubſtances.*



oil

oil is once depriv'd of, the bodies loſe their taſte: and therefore whatever has the power thus to draw away this ſpirit from the oil, has the power of rendring bodies perfectly inſipid.

*Whence in foſſils.*

2. As to minerals, all of them are deſtitute of taſte, ſo long as they remain entire, and undiſſolved; but when once ſet afloat, they become vehemently ſapid and pungent: whence it is eaſy to conclude, that taſteleſs bodies may, according to the nature of the ſolvent, acquire ſtrong determinate and abominable taſtes. Thus fix'd ſalts, diſtill'd from inſipid ſand, become violently acid ſpirits; as ſpirit of nitre, oil of vitriol, &c. Taſteleſs ſulphur, by boiling in oil, becomes exceedingly nauſeous upon the palate. The inſipid body of ſilver, diſſolved in ſpirit of nitre, proves moſt intolerably bitter upon the tongue; yet becomes inſipid again when reduced from its vitriolic ſtate to *luna cornea*. And by the like treatment the body of lead is made to taſte ſweet, as in the *Saccharum Saturni*. Whence we may ſee what numberleſs ways there are of diverſifying, changing, and deſtroying the taſtes of bodies *.

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## Chemical History *of* COLOURS, *exhibiting, in a ſeries of* Problems, *the production, deſtruction, and changes thereof.*

*Variety of colours afforded by a black body.*

WE learn'd from our proceſſes upon antimony, that almoſt all kinds of colours are producible in that black ſolid body. Diſſolved in *Aqua regia*, it affords a yellowiſh ſulphur, and a white or greyiſh calx; which being ſublimed with an equal quantity of ſal-ammoniac, gives a very great variety of different hues; as we obſerv'd in obtaining the flowers thereof. And that in like manner colours may alſo be wonderfully produced and deſtroy'd in fluids, we ſhall ſhew in the following problems, with which we will cloſe the whole.

* Mr. *Boyle* hath admirably treated theſe ſeveral ſubjects, in the chemical way, with a view to ſhew that all the particular qualities of bodies are mechanically producible; that is, by a bare alteration in the form or figure of their parts.

PRO-

## PROBLEM I.

1. *To turn a pellucid liquor instantly black, by barely pouring it into a clean glass; or by the addition of a white, red, or a gold-colour'd substance.*

2. Wash a glass in the clear solution of the vitriol of iron, made in fair water; and pour into it a slight and pellucid infusion of *Asiatic* galls, made also with water; and the liquor will immediately become black.

3. In the same manner, the transparent liquor or infusion of galls may be changed to a black, by throwing the smallest bit of a white or a red body into the glass; *viz.* a very little of the vitriol of iron, calcined to either a white or red.

4. To turn the transparent liquor black by a gold-colour'd substance, let fall a single drop of *Basil Valentine*'s golden tincture of iron therein, and this will effect the change, tho scarce one thousandth part thereof be iron; which nevertheless is the whole thing that produces the change.

5. These experiments are order'd to be made with the artificial vitriol of iron; but the native may serve the turn: so likewise might the *Ens veneris*, which is prepar'd from native vitriol, reduced to colcothar, and sublimed with sal-ammoniac. For the effect would be nearly the same, except that the blackness produc'd would not be so full when the *Ens veneris* was employ'd; because the sal-ammoniac acting here as an alkali would somewhat hinder the striking of the colour.

6. Nor need the experiment be confin'd to the infusion of galls alone; sage, oak-leaves, pomegranate bark, or flowers, good green tea, red rose-leaves, *&c.* may be used instead thereof: a clear tincture or infusion of any of these turning black with a solution of vitriol, or other chalybeate liquors.

## PROBLEM II.

1. *To make a black liquor pellucid by barely pouring it into a clean glass.*

2. Pour the black liquor already made, into a clear glass, wash'd with oil of vitriol; and it will presently become as clear and colourless as water.

3. The black liquor made from a solution of the vitriol of iron, will by this means become perfectly pellucid; but that prepar'd from colcothar, or vitriol calcined to redness, will only be brought to a yellowish colour, like

canary; on account of the predominant colour of the ſulphur of the vitriol ſo high calcined. That made with *Valentine*'s golden tincture of iron, will alſo remain inclining to yellow; and that with the *Ens veneris*, will afterwards turn ſomething milky.

## PROBLEM III.

1. *To turn the foregoing tranſparent liquor black again.*

2. Pour into it a little oil of tartar made *per deliquium*, which will ſo mortify the acid that before took away the blackneſs, as to make it preſently return again. But if the liquor ſhould be made with *Ens veneris*, it will appear only of a purpliſh colour, tending to black.

## PROBLEM IV.

1. *To render this black liquor again pellucid.*

2. Pour more oil of vitriol to it.

## PROBLEM V.

1. *To change a pellucid liquor yellow, and milky, by pouring it into two clean glaſſes.*

2. Pour the clean ſolution of quick-ſilver in *Aqua fortis*, into two clean glaſſes, the one whereof has been rinſed with oil of tartar *per deliquium*, and the other with ſpirit of ſal-ammoniac; and in the former the liquor will turn yellow, and the other milky.

3. This gives us a remarkable inſtance of a difference between a fix'd and volatile alkali.

## PROBLEM VI.

1. *To deſtroy the yellow and milky colours produced in the preceding problem.*

2. Drop ſpirit of nitre, or ſpirit of vitriol into them.

## PROBLEM VII.

1. *To turn a transſparent red liquor milky, by barely pouring it into a clean glaſs.*

2. Pour the tincture of ſulphur, prepar'd with fix'd alkali and alcohol, into a clean glaſs waſh'd in ſome acid ſpirit, and it will immediately turn milky; as in the preparation of *Lac Sulphuris.*

## PROBLEM VIII.

1. *To change the white liquor of the preceding problem green.*

2. Drop into it a little oil of tartar, well diluted with water.

## PROBLEM IX.

1. *To turn a pellucid liquor of a beautiful violet-colour, upon pouring it into a clean glaſs.*

2. Pour a clear ſolution of copper made in ſpirit of vinegar, and well diluted with water, into a glaſs waſh'd with ſpirit of ſal-ammoniac, or ſpirit of urine.

## PROBLEM X.

1. *To deſtroy the violet-colour produced in the preceding liquor, by barely pouring it into a clean glaſs.*

2. Pour the liquor into a clean glaſs waſh'd with oil of vitriol.

## PROBLEM XI.

1. *To change the liquor of the laſt problem, to a blue or ſea-green.*

2. Drop into it a little oil of tartar *per deliquium.*

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## PROBLEM XII.

1. *To make a rich beautiful green liquor paſs thro various degrees of colours, into a fine sky-blue, or violet.*

2. Make a ſolution of copper with diſtill'd vinegar, which will be of a lovely green; and pour to it by degrees the ſpirit of ſal-ammoniac, and it will paſs thro various ſhades to a fine sky-blue, or violet.

## PROBLEM XIII.

1. *To reduce the blue liquor of the laſt problem back to a green again.*

2. Pour any ſtrong acid, as oil of vitriol thereto, and it will paſs thro' all the ſhades, till at length it ends in a green; from whence it may again be brought to a blue by the affuſion of oil of tartar *per deliquium* *.

## PROBLEM XIV.

1. *To diſtinguiſh acids from alkalies, by the change of colour, they produce in the blue ſyrup of violets.*

2. Thoſe liquors which being poured to ſyrup of violets, change it of a fine red, or carmine colour, are accounted acid; and thoſe alkaline which turn it of a kindly green. Thus oil of vitriol, or any the lighteſt acid, will inſtantly change the blue of that ſyrup to a red; as oil of tartar, or any the lighter alkali, turns it green. And this is accounted a ſure criterion of acid and alkali. And if to this ſyrup, made red by the addition of oil of vitriol, oil of tartar be poured, it turns that part wherewith it comes in contact green; but leaves all the other red. In like manner, if to a quantity of the ſyrup made green by oil of tartar, a ſufficient or predominant proportion of oil of vitriol be added, it turns that part red which it touches, and leaves all the other part green. And ſo when larger quantities of acid and alkaline liquors are alternately mix'd

* This kind of problems might be varied *ad infinitum*. Whoever deſires to ſee more experiments of this kind, and the doctrine they appear to eſtabliſh, may conſult Mr. *Boyle* upon *Colours*, and Sir *Iſaac Newton's Optics*.

with the blue ſyrup of violets, they ſuddenly change it from red to green, and from green to red. And all this being conſider'd, together with what we formerly obſerv'd as to the mixture of oils and water, which makes a white, and other particulars of the like nature, will lead us into a knowledge of the inſtantaneous production, change and deſtruction of *Colours.*

*F I N I S.*